

Gas Detectors

9/15/2010

Contents

Introduction

Types of Gas Detectors

Ionization of the Detector Gas

Electrodes

Basic electrode Configurations

Parallel Plate Electrodes

Coaxial Electrodes

Movement of Ion Pairs to Electrodes

Beta Particle Interaction with the Detector

Alpha Particle Interaction with the Detector

Photon Interaction with the Detector

Radiation Type and Size of Detector Signal

Modes of Operation

Contents

Current Mode of Operation

General

Example

Pulse Mode of Operation

Pulse Characteristics: Voltage (V)

Pulse Characteristics: Current (I)

Pulse Characteristics: Charge (Q)

Making Pulse Height Related to the Collected Charge

Pulse Shape

Pulse Rise and the Maximum Voltage (V_{\max})

Pulse Tail and the Time Constant (τ)

Contents

The Six (or five) Region Curve

General

Recombination Region

Ionization Region

Proportional Region

Region of Limited Proportionality

Geiger-Mueller region

Continuous Discharge

Know the Difference between These Curves

Introduction

Introduction

Types of Gas Detectors

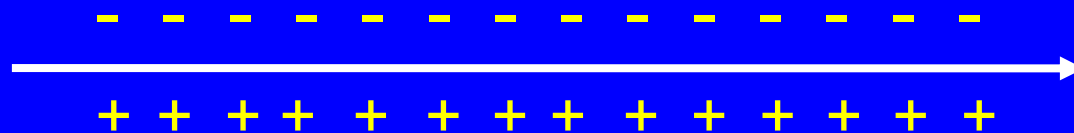
There are three types of gas detectors:

1. Ionization chamber
2. Proportional counter
3. Geiger Mueller counter

Introduction

Ionization of the Detector Gas

They are referred to as gas detectors because the signal is produced when charged particles ionize the gas in the detection chamber.



If the gas is neon (the most common gas in a GM detector), the positive member of each ion pair is a neon ion (Ne^+) while the negative member of the pair is a freed electron (e^-).

If the detector gas is air, the positive member of the ion pair is usually a positively charged nitrogen molecule (N_2^+) and the negative member of the ion pair is the freed electron (e^-).

Introduction

Ionization of the Detector Gas

The term “ion” usually refers to the positive member of the pair. Sometimes the electron is also referred to as an ion.

In the absence of an electric field, the ion pairs created in the gas of the detector simply recombine.

However, if the ionization occurs between two oppositely charged electrodes, and if the electric field is sufficiently strong, the positive and negative members of the ion pairs will separate and be collected at the electrodes.

Introduction

Electrodes

An electric field is established by creating an potential difference between two electrodes. The potential difference is the voltage applied across the electrodes.

Anode: the positively charged electrode

Cathode: the negatively charged electrode

In most systems, the cathode is grounded. That way an individual touching the cathode won't receive a shock. The cathode is still negative with respect to the anode however.

Introduction

Basic Electrode Configurations

There are two general electrode configurations:

1. Parallel plate electrodes
2. Coaxial electrodes

Variations on these configurations are common and the situation in a given instrument might only approximate one of them.

Calculating the strength of the electric field is straightforward for the parallel plate and coaxial configurations, but it can be far more complicated in a real instrument.

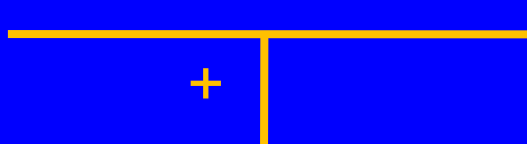
Introduction

Parallel Plate Electrodes

Parallel plate electrodes are only used in ionization chambers. Nevertheless, many ion chambers employ a coaxial configuration. Parallel plate configurations are most common for the ion chambers used in radiology.

As the name implies, the two electrodes are parallel plates arranged as shown in the following diagram.

Cathode 

Anode 

Introduction

Parallel Plate Electrodes

The strength of the electric field is:

$$\textit{Electric Field Strength } (\xi) = \frac{V}{d}$$

ξ is the strength of the electric field (e.g., volts /meter)

V is the potential difference (e.g., volts)

d is the distance between the two plates (e.g., meters)

The strength of this field is uniform – it is the same throughout the space between the electrodes.

Introduction

Coaxial Electrodes

The coaxial electrode configuration, or a variant thereof, is far more common than the parallel plate configuration.

In the most typical coaxial configuration, the cathode is a cylinder that serves as the detector chamber wall. In some cases, the cathode is a conductive coating on the inside of the chamber wall.

The anode consists of a central wire running that runs along the chamber's axis.

Introduction

Coaxial Electrodes

$$\textit{Electric Field Strength } (\xi) = \frac{V}{r \ln\left(\frac{b}{a}\right)}$$

ξ is the strength of the electric field (e.g., volts /meter)

V is the potential difference (e.g., volts)

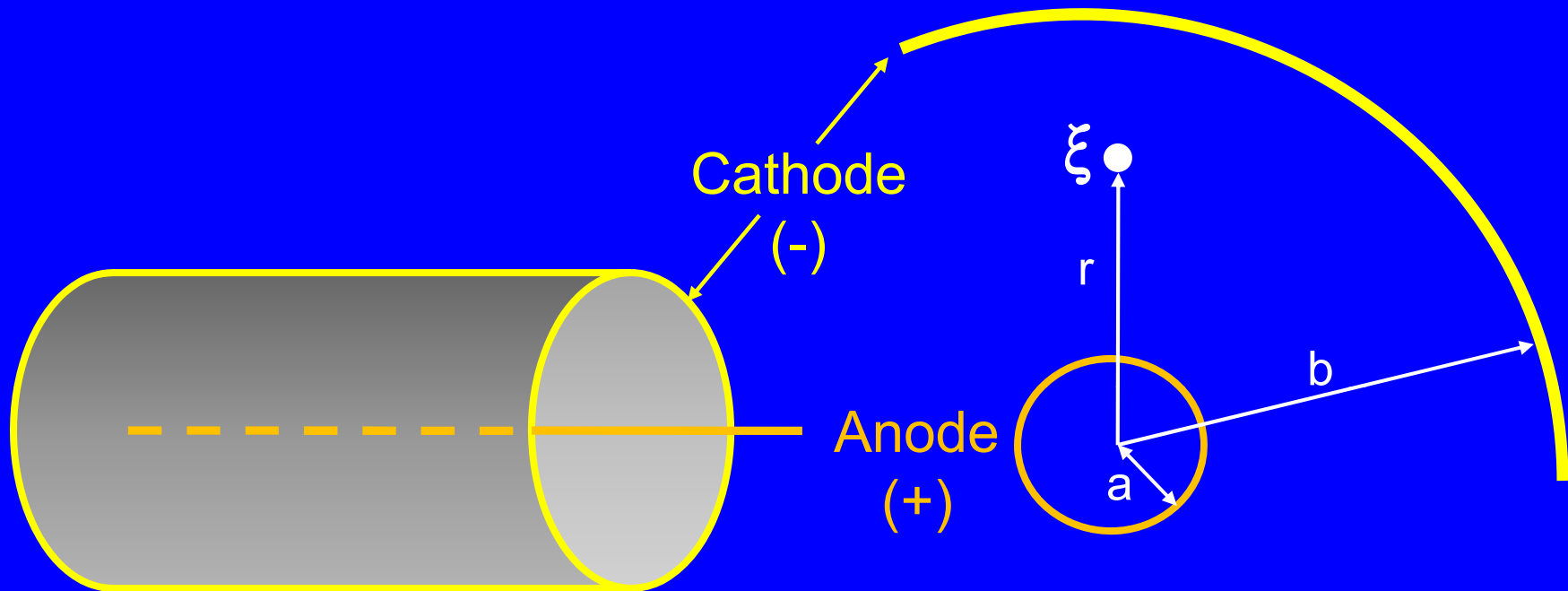
r is the radial distance from the anode center to the point at which the electric field strength is calculated (e.g., meters)

a is the anode radius (e.g., meters)

b is the cathode radius (e.g., meters)

Introduction

Coaxial Electrodes



The strength of the electric field varies throughout the chamber volume. It increases rapidly as we move towards the central electrode and decreases as we move towards the outer electrode.

Introduction

Movement of Ion Pairs to Electrodes

If the electric field strength is sufficiently large, the ion pairs won't recombine. The electrons move to the anode and the positively charged gas ions move towards the cathode.

The drift velocity is the velocity at which the ions move towards the electrodes. It is given by the following formula:

$$\text{Drift Velocity } (v) = \mu \frac{\xi}{\rho}$$

ξ is the electric field strength (e.g., V/m)

v is the drift velocity (e.g., m/s)

μ is the mobility factor of the ion (e.g., m² atm/V s)

ρ is the gas pressure (e.g., atmospheres)

Introduction

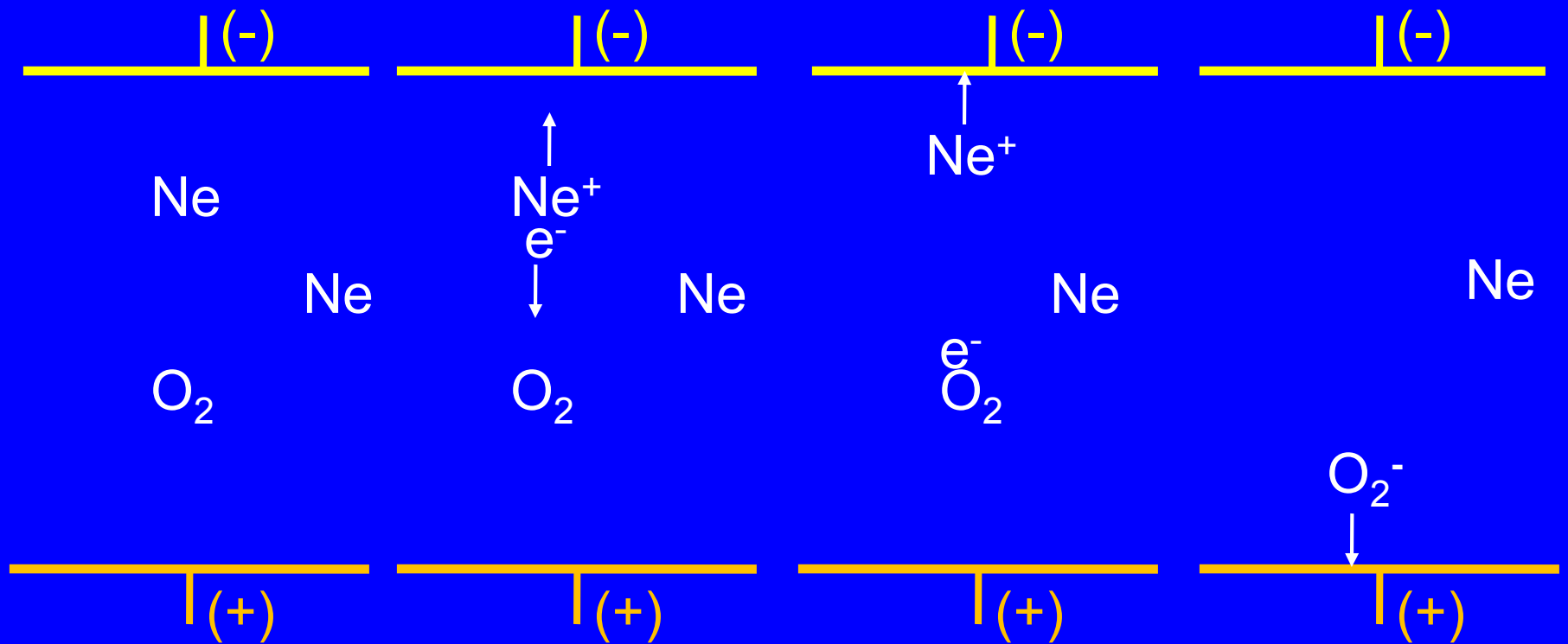
Movement of Ion Pairs to Electrodes

Positively charged gas ions take approximately 10 milliseconds to reach the cathode in a typical detector - their mobility constant is about $1.3 \times 10^{-4} \text{ m}^2 \text{ atm/V s}$. Since the mobility constant for electrons is roughly 1000 times larger, electrons reach the anode in microseconds.

As the positive ions and electrons move to the electrodes, they collide with various gas molecules and sometimes transfer their charge to those molecules (depending on the latter's electro-negativity). If an electron collides with a highly electronegative molecule (e.g., O_2), the electron will be captured and the now negatively charged gas molecule rather than the electron proceeds to the anode..

Introduction

Movement of Ion Pairs to Electrodes over Time

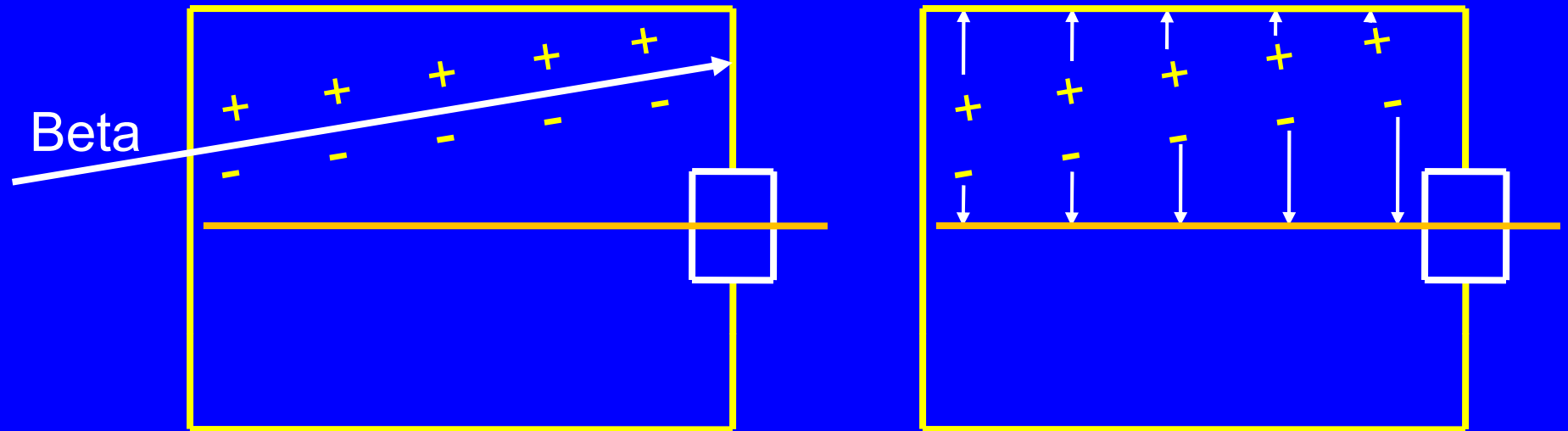


A neon atom is ionized.
The neon ion goes to the cathode and the electron heads towards the anode

The electron collides with an O₂ molecule and is captured. The negative O₂ ion goes to the anode.

Introduction

Beta Particle Interaction with the Detector

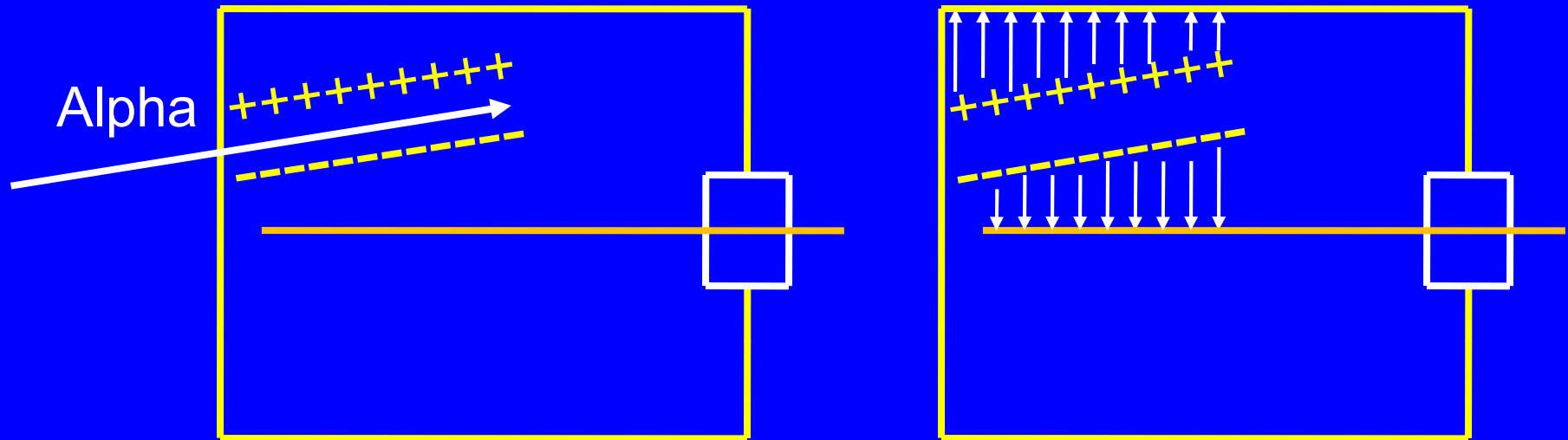


The average energy lost by a charged particle per ion pair produced is approximately 34 eV. Since a typical electron/beta particle produces 100 ion pairs per cm of travel, a 1 Mev electron might have a range of 300 cm.

Given the size of a typical gas detector, beta particles usually transfer a small portion of their energy to the detector gas. 19

Introduction

Alpha Particle Interaction with the Detector

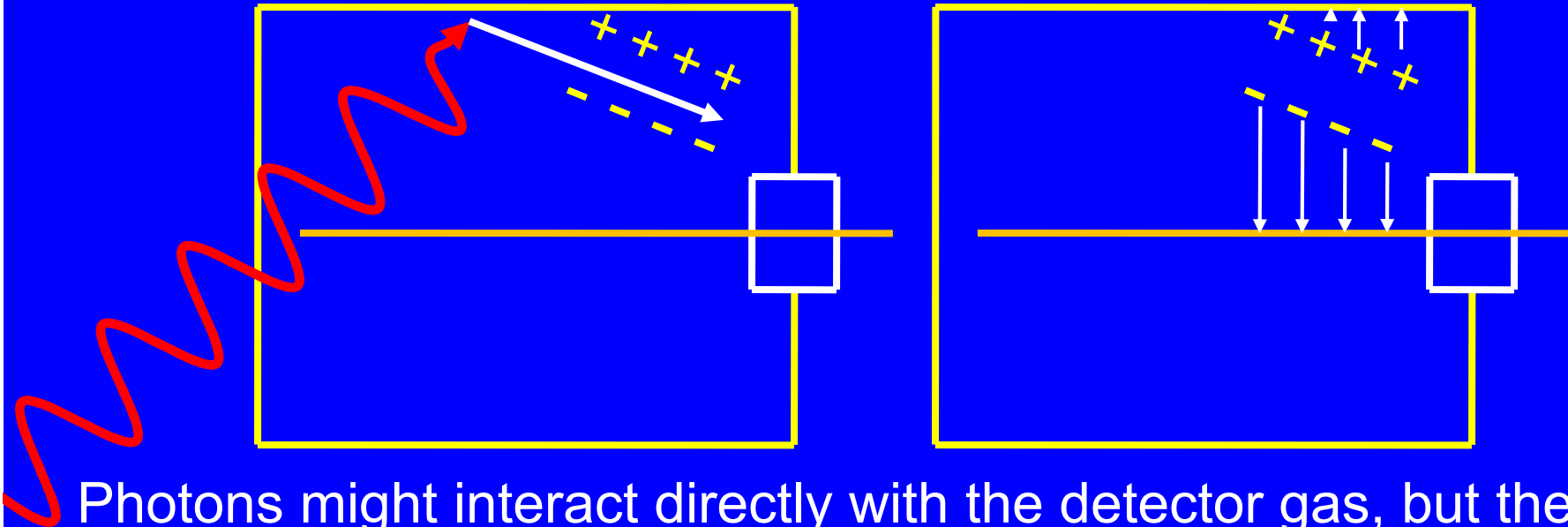


The average energy lost by a charged particle per ion pair produced is approximately 34 eV. A typical alpha particle produces 40,000 ion pairs per cm. As such, a 6 Mev alpha particle will have a range of about 4.5 cm.

Given the size of a typical gas detector, it is possible for some alpha particles to expend all their energy in the detector gas.

Introduction

Photon Interaction with the Detector



Photons might interact directly with the detector gas, but they are more likely to interact with the detector wall (the cathode).

In some of these interactions, an electron is “knocked off” the detector wall. This electron then traverses the gas inside the detector chamber. This electron might, or might not, have sufficient energy to cause further ionizations.

Introduction

Radiation Type and the Size of the Detector Signal

With ion chambers and proportional counters, the magnitude of the detector signal depends on the number of ion pairs produced in the gas by the incident charged particle.

In general, but not always, the largest to smallest signal would be produced by:

Alpha particles (largest signal)

Beta particles

Photons (smallest signal)

Introduction

Modes of Operation

A gas detector can operate in one of two modes:

1. Current Mode
2. Pulse mode

Ion chambers usually operate in the current mode because their pulses are too small to be easily distinguished from electronic noise.

Proportional counters and Geiger Mueller detectors usually operate in the pulse mode.

Current Mode of Operation

Current Mode of Operation

General

In the current mode, the system measures the current from the detector chamber rather than count the pulses.

The detector calibration relates the current to a quantity such as the exposure rate (e.g., R/hr).

Current (I) is measured in units of amperes (A).

$$1 \text{ ampere} = 1 \text{ coulomb per second}$$

The current from a radiation detector is very small, often on the order of picoamperes (pA).

Current Mode of Operation

General

Current is charge per unit time, e.g., coulombs per second

$$I = Q/t$$

I is current (amperes)

Q is the collected charge (coulombs)

t is the time (seconds)

$$Q = n e$$

n is the number of collected electrons

e is the charge on each electron (1.6×10^{-19} C)

Current Mode of Operation

Example

If one million electrons are collected by the anode over a time period of 10.7 ns (1.07×10^{-8} s), what is the current?

$$I = Q/t$$

$$\begin{aligned} Q &= n e \\ &= 10^6 \times 1.6 \times 10^{-19} \text{ C} \\ &= 1.6 \times 10^{-13} \text{ C} \end{aligned}$$

$$\begin{aligned} I &= Q/t \\ &= 1.6 \times 10^{-13} \text{ C} / 1.07 \times 10^{-8} \text{ s} \\ &= 1.5 \times 10^{-5} \text{ C/s} \\ &= 1.5 \times 10^{-5} \text{ amperes} \end{aligned}$$

Current Mode of Operation

Example

If it took 8 nanoseconds (instead of 10.7) for the electrons to reach the anode, the current is:

$$\begin{aligned} I &= 1.6 \times 10^{-13} \text{ C} / 8 \times 10^{-9} \text{ s} \\ &= 2.0 \times 10^{-5} \text{ amperes} \end{aligned}$$

If it took 16 nanoseconds, the current is:

$$\begin{aligned} I &= 1.6 \times 10^{-13} \text{ C} / 16 \times 10^{-9} \text{ s} \\ &= 1.0 \times 10^{-5} \text{ amperes} \end{aligned}$$

In each of these three cases, exactly the same amount of ionization occurred in the detector gas and exactly the same charge was collected at the anode.

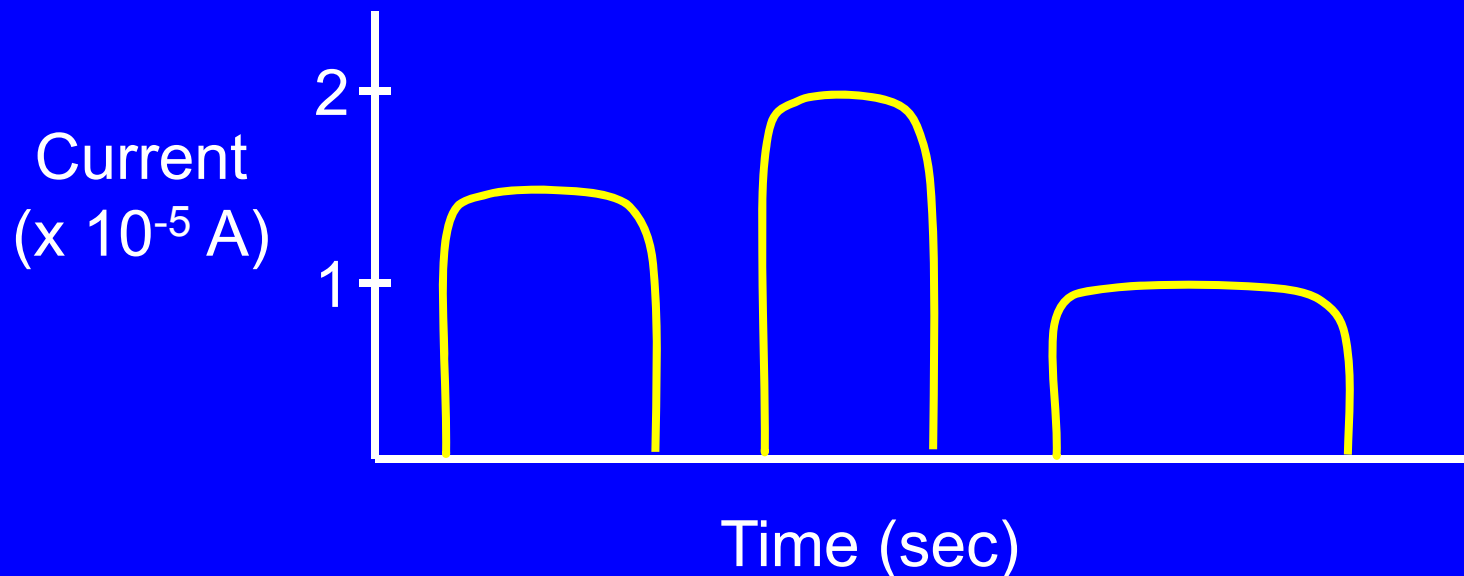
Current Mode of Operation

Example

The following figure shows the current as a function of time during these three “pulses.”

The area of each is the charge. It is the same for all three.

$$\text{Charge (coulombs)} = \text{current (amperes)} \times \text{time (sec)}$$



Current Mode of Operation

Example

When a detector operates in the current mode, the electronics average the current over some period of time.

In this example, we imagine that the detector integration period is 100 nanoseconds (1×10^{-7} s).

The averaged current from the detector is:

$$\begin{aligned} I &= Q/t \\ &= 4.8 \times 10^{-13} \text{ C} / 1 \times 10^{-7} \text{ s} \\ &= 4.8 \times 10^{-6} \text{ amperes} \end{aligned}$$

Pulse Mode of Operation

9/8/2008

Pulse Mode of Operation

Pulse Characteristics: Voltage (V)

As long as the detector gas is not ionized, the potential difference between the anode and cathode is constant (e.g., 900 volts).

During the movement of the electrons and positive ions to the electrodes, the potential difference decreases.

After some period of time, the voltage stops decreasing and returns to the baseline voltage.

This decrease and recovery in the voltage is the pulse. The maximum change in the voltage is the pulse height (amplitude).

Pulse Mode of Operation

Pulse Characteristics: Current (I)

The movement of electrons to the anode induces a current from the anode during each pulse.

The magnitude of the current depends on the pulse charge and the duration of the pulse.

$$I = Q/t$$

I is the current in amperes

Q is the charge in coulombs

t is the time in seconds

Pulse Mode of Operation

Pulse Characteristics: Charge (Q)

The charge (Q) of the pulse is the charge on the electrons reaching the anode.

$$Q = n e$$

Q is the collected charge in coulombs

n is the number of electrons reaching the anode

e is the charge on an electron (1.6×10^{-19} coulombs)

The charge is the only pulse characteristic that is always related to the energy deposited in the detector gas.

Pulse Mode of Operation

Analyzing the Pulses

When a detector operates in the pulse mode, we might:

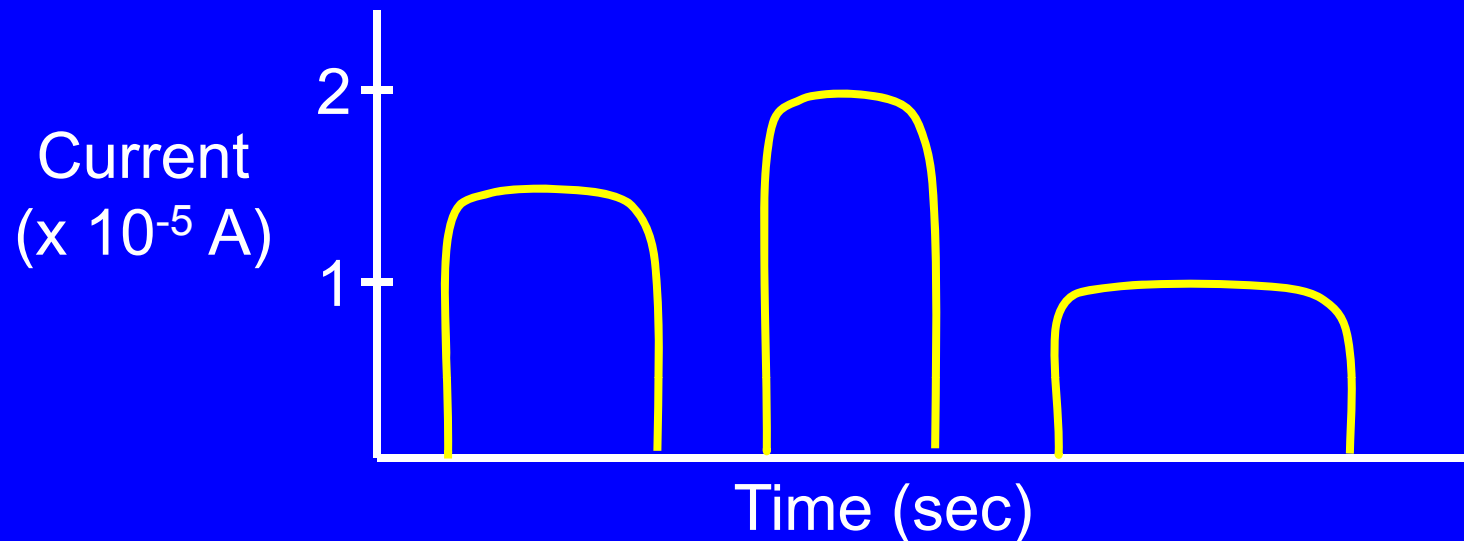
1. Count the pulses, and/or
2. Measure the pulse height (amplitude)

For the pulse height to carry useful information about the energy deposited in the detector gas, it must be directly related to the collected charge.

As the following discussion indicates, a proper choice of the time constant (τ) is necessary for the pulse height to be related to the collected charge.

Pulse Mode of Operation

Making Pulse Height Related to the Collected Charge



Here we see the detector current as a function of time for three ionizing events. Each event deposits the same energy in the detector gas. The collected charge (number of electrons and ions reaching the electrodes) is the same in each case. The area of each “pulse” (current x time) is the collected charge.

Pulse Mode of Operation

Making Pulse Height Related to the Collected Charge

Time Constant (τ) \ll charge collection time

The figure on the following slide shows pulse size (volts) as a function of time when the time constant is much shorter than the charge collection time.

The pulse width indicates the charge collection time.

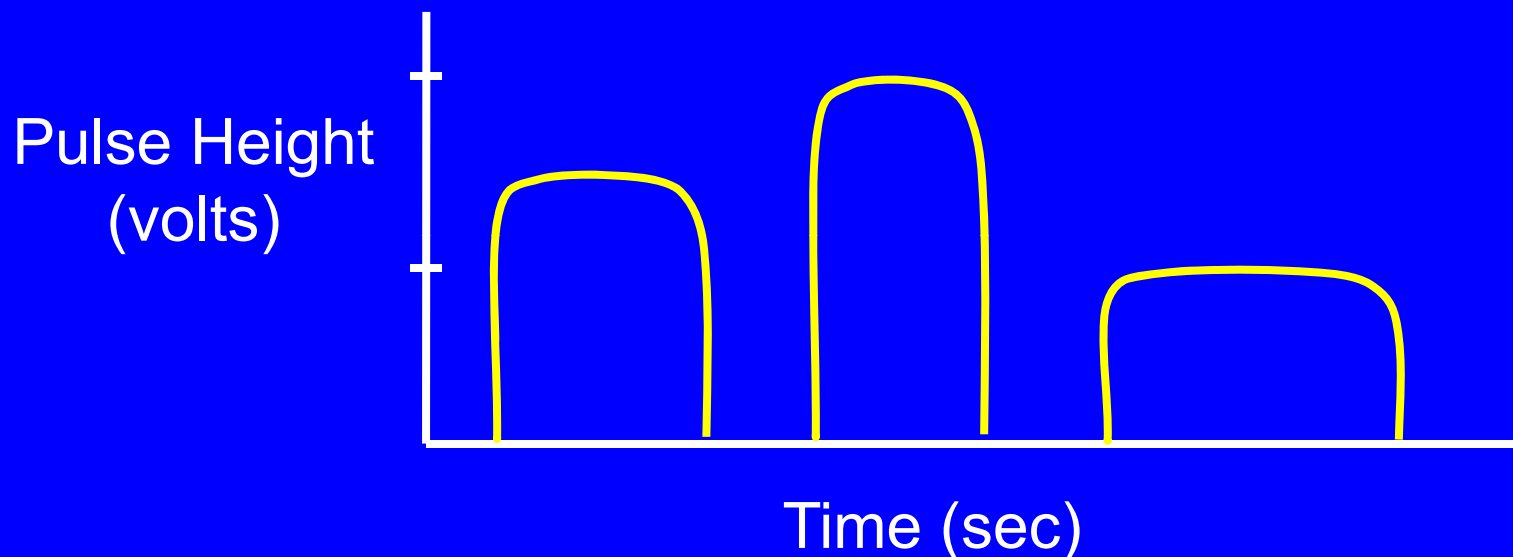
Since the time constant is small, the electronics present no resistance to the current. In addition, the system lacks the capacitance to accumulate a charge.

The potential difference (voltage) reflects the instantaneous charge in the circuit rather than the total collected charge. 37

Pulse Mode of Operation

Making Pulse Height Related to the Collected Charge

Time Constant (τ) \ll charge collection time



The bottom line is that the pulse height doesn't reflect the energy deposited in the detector gas (total collected charge).

In other words, the pulse height carries no useful information.

Pulse Mode of Operation

Making Pulse Height Related to the Collected Charge

Time Constant (τ) \gg charge collection time

The figure on the next slide also shows pulse size as a function of time. But in this case, the time constant is much greater than the charge collection time.

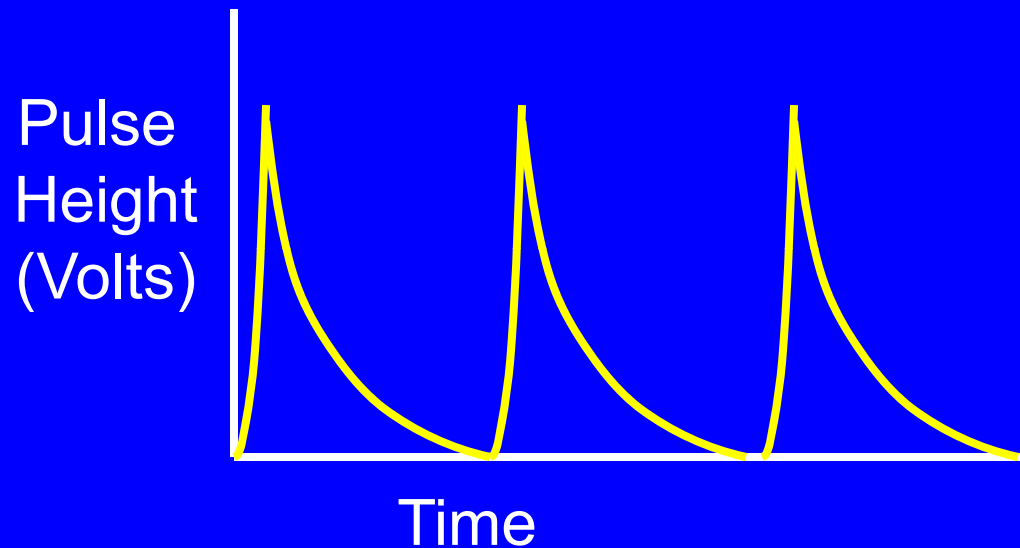
The large resistance to the current and the large capacitance of the electronics means that the current is “held up” - this causes the potential difference (volts) to build up to the potential maximum voltage.

The maximum pulse height now reflects the energy deposited in the detector gas. This is potentially useful information!

Pulse Mode of Operation

Making Pulse Height Related to the Collected Charge

Time Constant (τ) \gg charge collection time

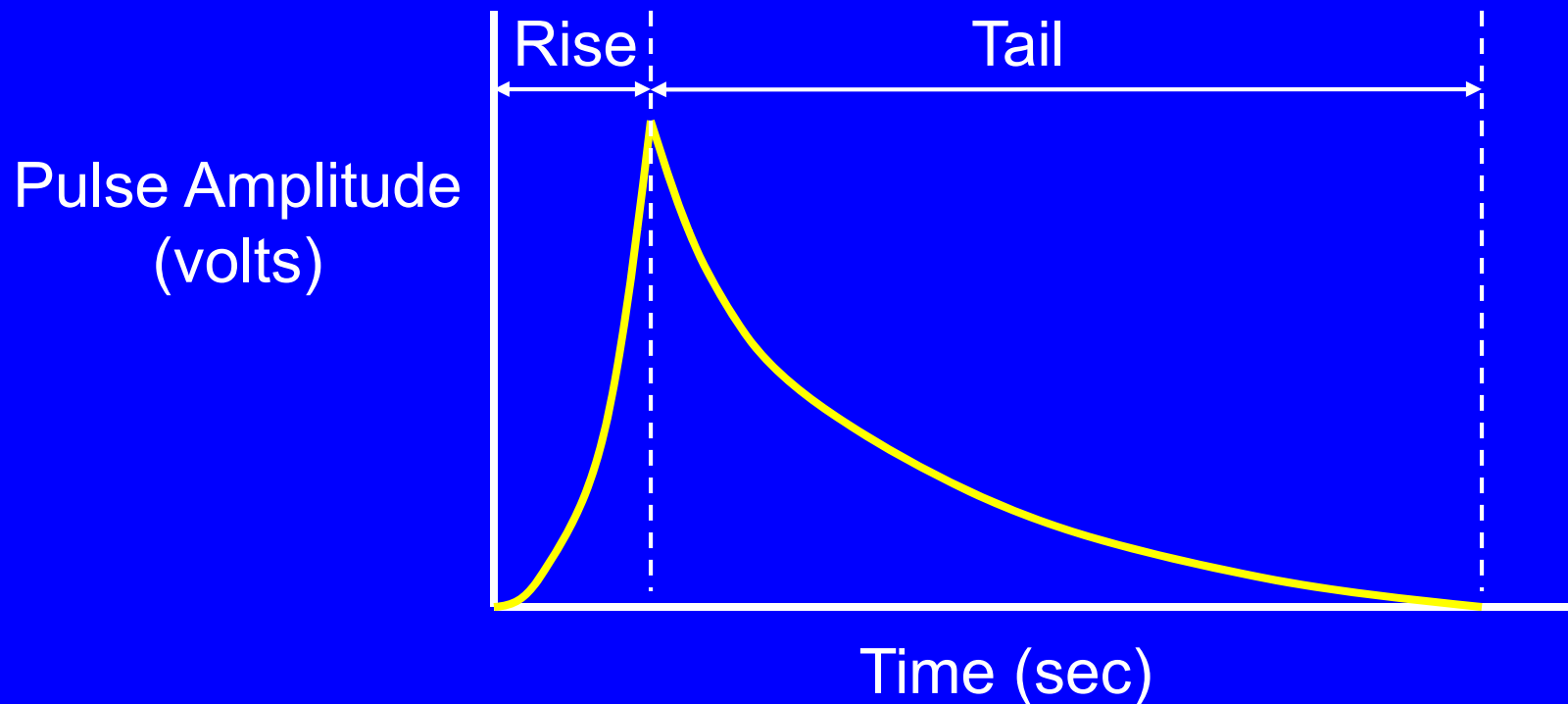


The output pulse from the detector is negative, i.e., the voltage decreases. Nevertheless, it is common to illustrate the pulse as if it were positive.

Pulse Mode of Operation

Pulse Shape

Time Constant (τ) \gg charge collection time



The pulse has two components: a rise and a tail.

Pulse Mode of Operation

Pulse Rise and the Maximum Voltage (V_{\max})

Time Constant (τ) \gg charge collection time

The time that the pulse takes to reach its maximum voltage (rise time) is determined by the charge collection time.

When the maximum voltage is directly related to the collected charge ($\tau \gg$ charge collection time):

$$V_{\max} = \frac{Q}{C}$$

V_{\max} is the maximum voltage decrease (volts)

Q is the charge collected at the anode (coulombs)

C is the detector capacitance (farads)

Pulse Mode of Operation

Pulse Tail and the Time Constant (τ)

Time Constant (τ) \gg charge collection time

The rate at which the pulse returns to the baseline voltage is controlled by the electronic characteristics of the system.

Specifically, the length of the pulse tail is determined by the time constant. The time constant is calculated as follows:

$$\tau = R C$$

τ is the time constant (seconds)

R is the circuitry (e.g., preamplifier) input resistance (ohms)

C is the circuitry and detector capacitance (farads)

Pulse Mode of Operation

Pulse Tail and the Time Constant (τ)

Time Constant (τ) \gg charge collection time

The following equation gives the voltage at any time after the pulse has reached its maximum amplitude:

$$V_t = V_{\max} e^{-\frac{t}{\tau}}$$

V_{\max} is the maximum voltage at time $t = 0$

V_t is the tail's voltage at time t

τ is the circuitry time constant

The time constant is analogous to a half life: If the time constant is short, the tail is short. If the time constant is large, the pulse has a long tail.

The Six (or five) Region Curve

Six Region Curve

General

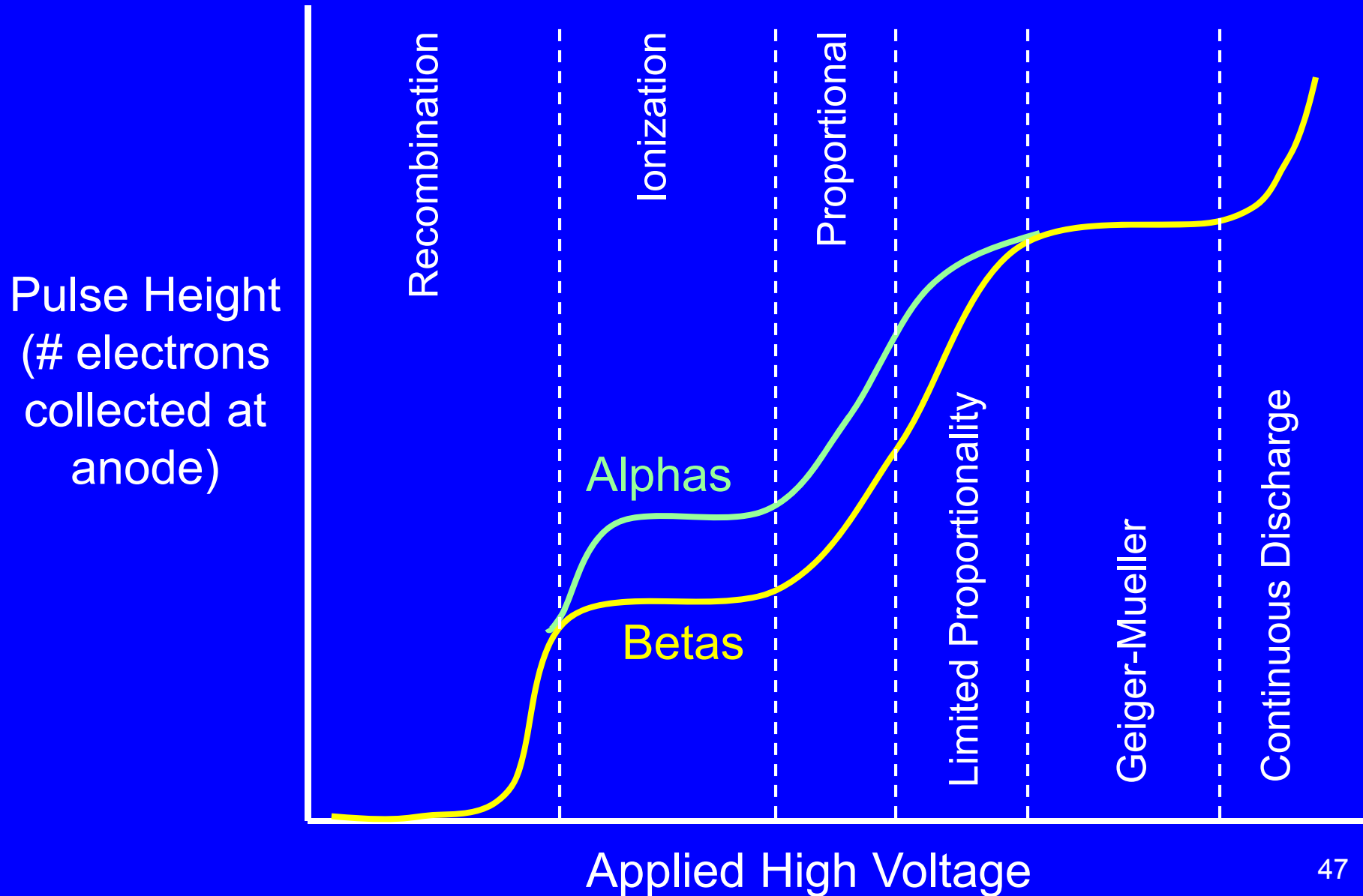
The six region curve is a plot of pulse height as a function of the high voltage applied to a gas detector.

It is sometimes depicted as a five region curve with the proportional region and the region of limited proportionality merged together.

It indicates that theoretically a single detector can function as an ionization chamber, proportional counter or Geiger-Mueller detector depending on the applied high voltage.

When interpreting it, it can be helpful to consider the pulse height as the number of electrons collected at the anode.

The Six Region Curve



Six Region Curve

General

This curve, which applies to a single detector, shows the Geiger-Mueller region at a higher voltage than the proportional region.

In practice, there are design differences between Geiger-Mueller tubes and proportional counters that cause most Geiger-Mueller detectors to operate at lower voltages than most proportional counters.

Six Region Curve

1. Recombination Region

At the lowest voltages, the strength of the electric field is sufficiently low that many of the primary ion pairs created in the gas by the incident charged particle (e.g., alpha, beta) simply recombine.

If no electrons reach the anode - there is no pulse.

Six Region Curve

2. Ionization Region

In the ionization region, the electric field is just strong enough to prevent recombination of the ion pairs produced in the gas.

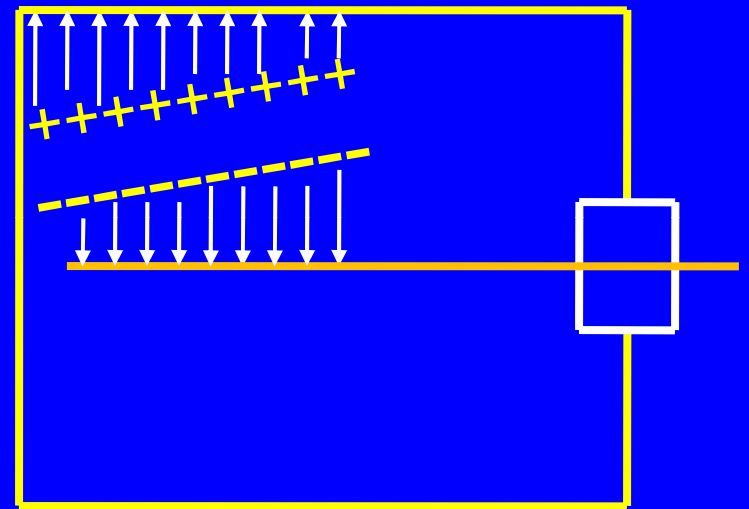
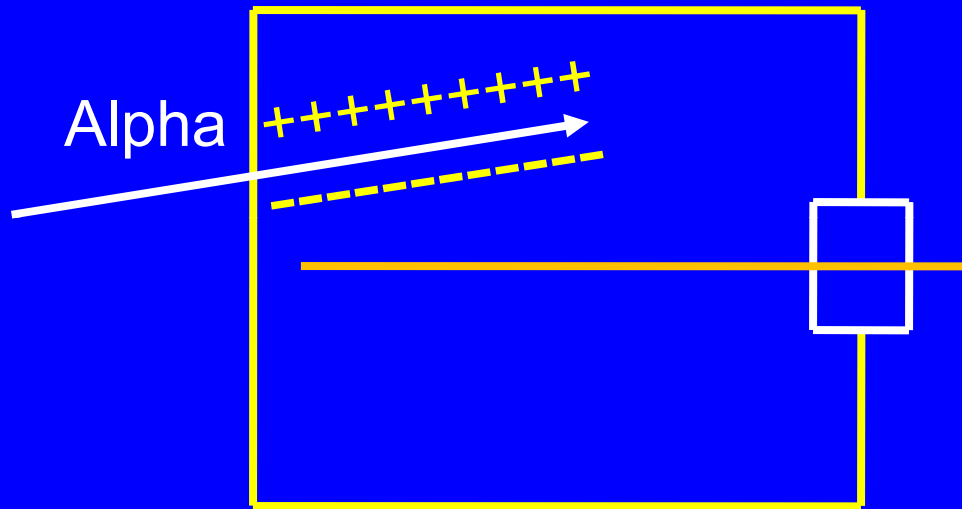
One electron reaches the anode for each primary ion pair created by the incident radiation. The curve (plateau) is flat because increasing the voltage doesn't increase the number of electrons reaching the anode.

The resulting current is referred to as a saturation current.

Since an alpha particle produces considerably more ion pairs than a beta particle, the alpha pulses are correspondingly larger.

Six Region Curve

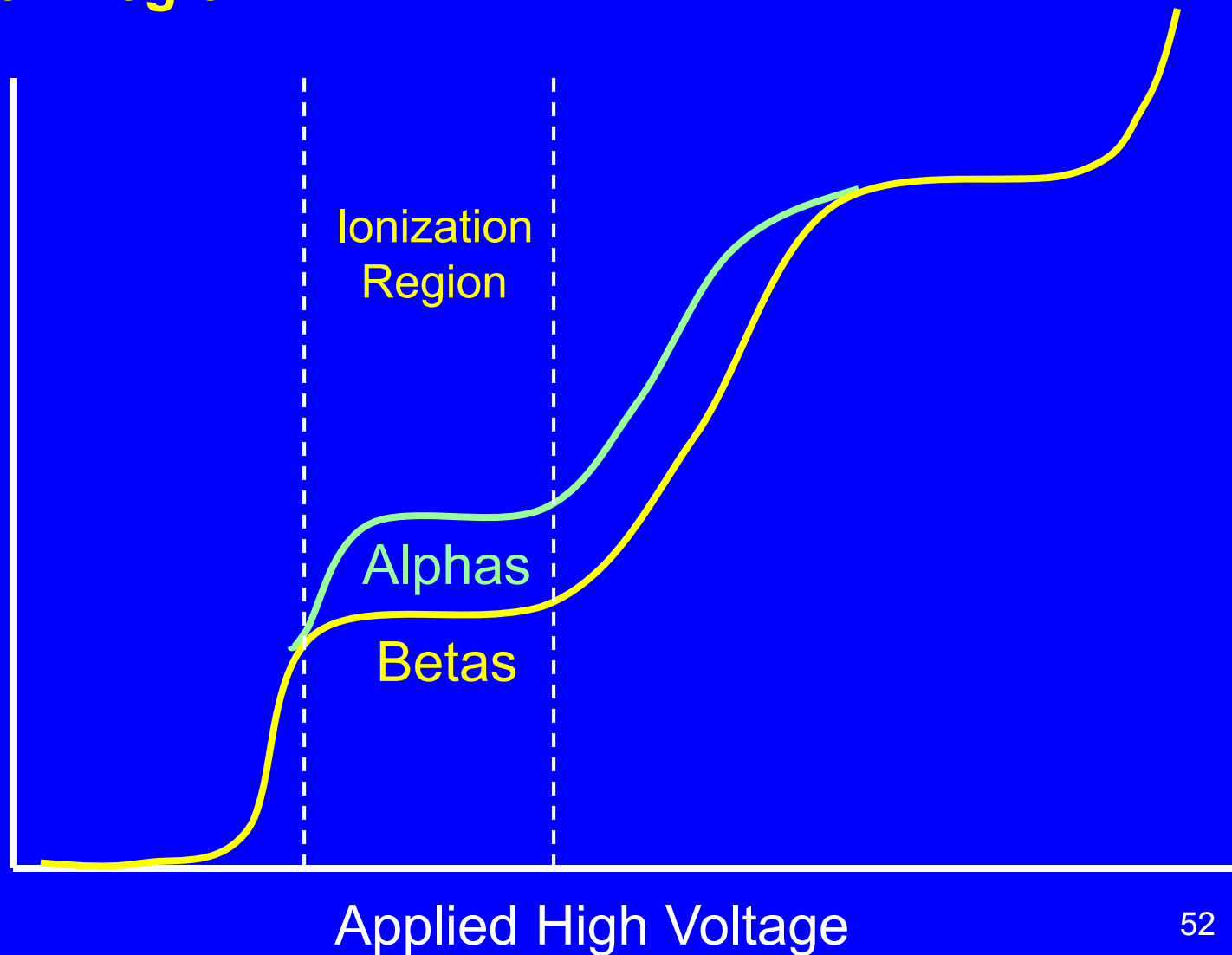
2. Ionization Region



Six Region Curve

2. Ionization Region

Pulse Height
(# electrons
collected at
anode)



Six Region Curve

3. Proportional Region

The applied high voltage is greater and the electric field is substantially stronger than in the ionization region.

As the electrons of the primary ion pairs move towards the anode, they gain kinetic energy. When they get close enough to the anode, the electric field is sufficiently strong (ca. 10^6 V/m), that these electrons gain enough kinetic energy to create secondary ion pairs.

The electrons produced in these secondary ion pairs, along with the primary electrons, continue to gain energy as they move towards the anode, and as they do, they produce more and more ionizations.

Six Region Curve

3. Proportional Region

The result is that each electron from the primary ion pairs produces a cascade, or avalanche of ion pairs (Townsend avalanche).

For every primary ion pair created in the chamber by the ionizing radiation, 10^2 to 10^4 electrons reach the anode. The increase in the number of electrons is referred to as the multiplication factor.

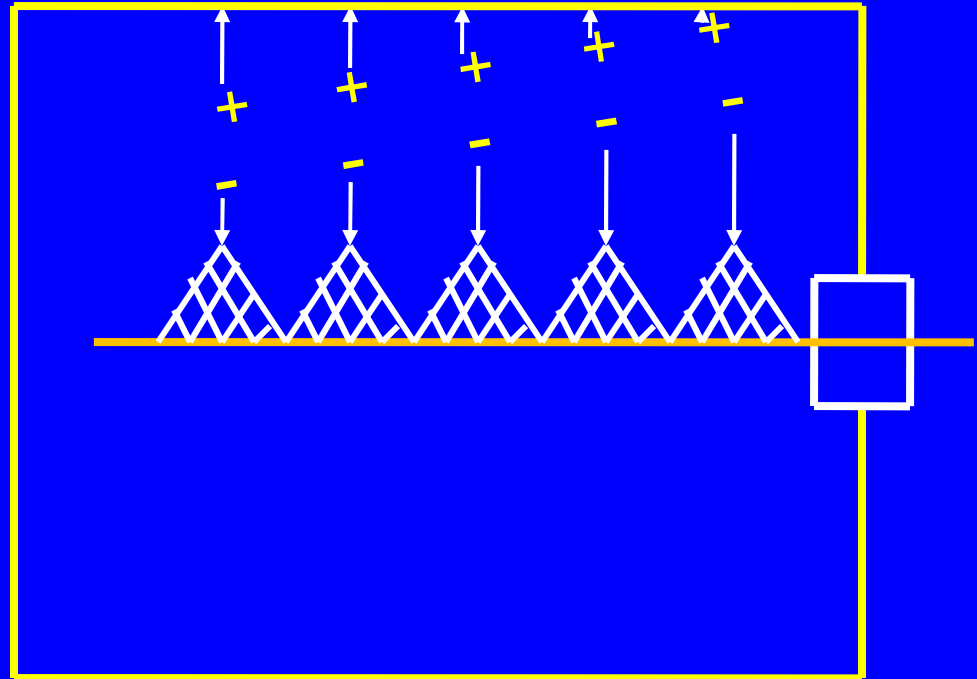
As the high voltage increases, the distance from the anode at which the field strength exceeds 10^6 V/m increases. As the avalanches are initiated further away from the anode, the multiplication factor (and pulse size) increases.

Six Region Curve

3. Proportional Region

The greater the number of primary ion pairs the larger the pulse.


The higher the voltage, the larger the avalanches and the larger the pulse.



The figure illustrates a single pulse consisting of simultaneous five avalanches.

Six Region Curve

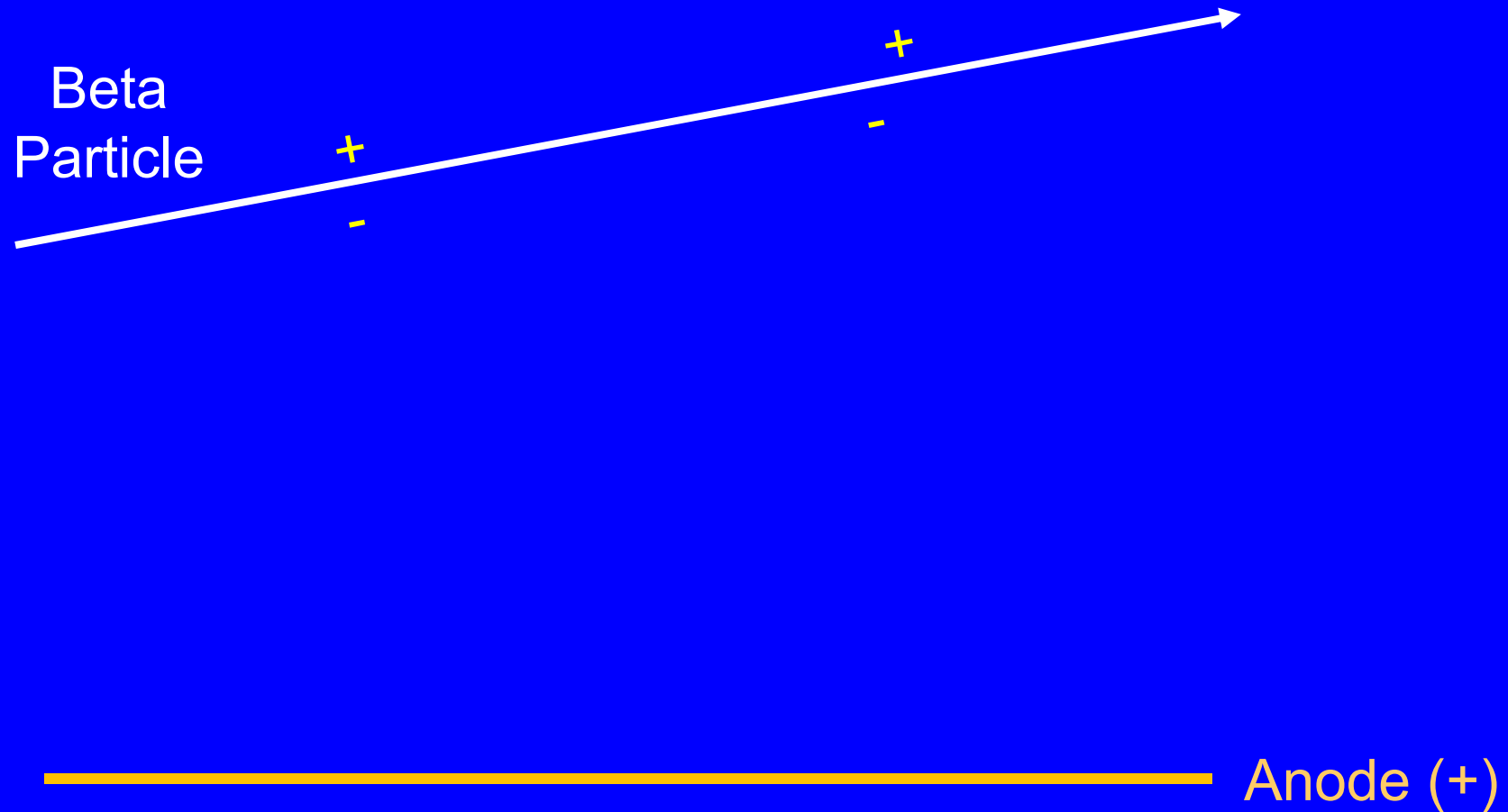
3. Proportional Region

Beta
Particle


 Anode (+)

Six Region Curve

3. Proportional Region



Six Region Curve

3. Proportional Region



————— Anode (+)

Six Region Curve

3. Proportional Region

+

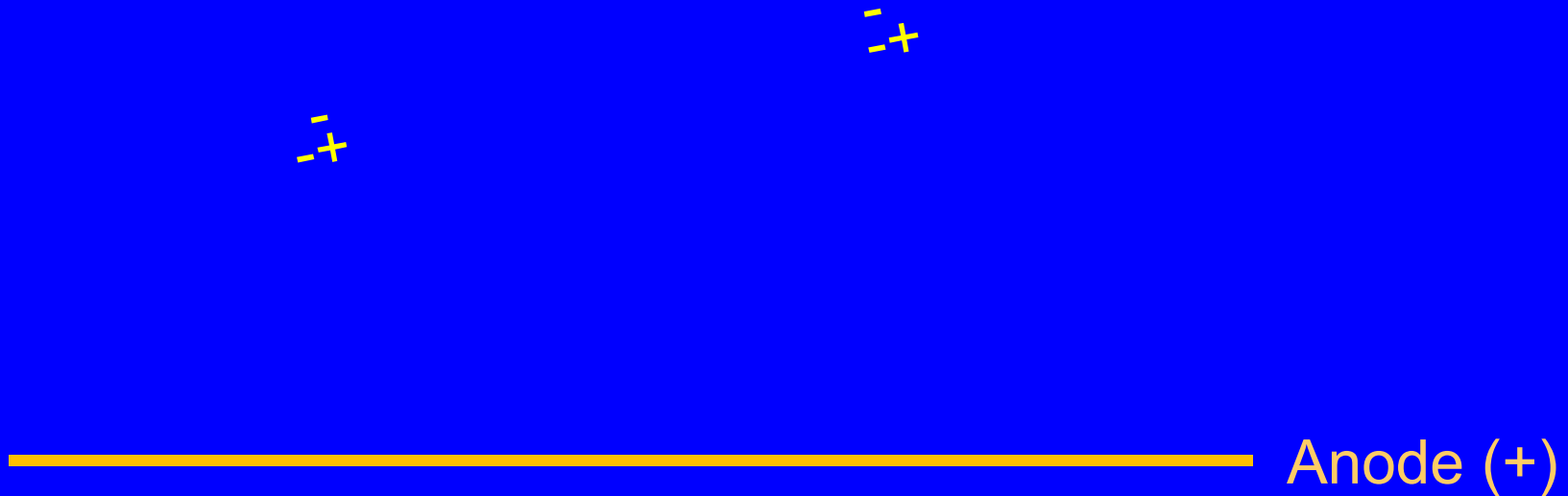
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-

————— Anode (+)

Six Region Curve

3. Proportional Region



Six Region Curve

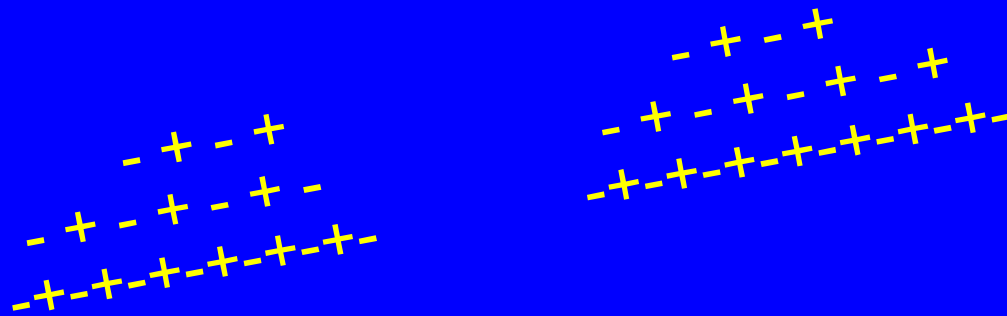
3. Proportional Region



————— Anode (+)

Six Region Curve

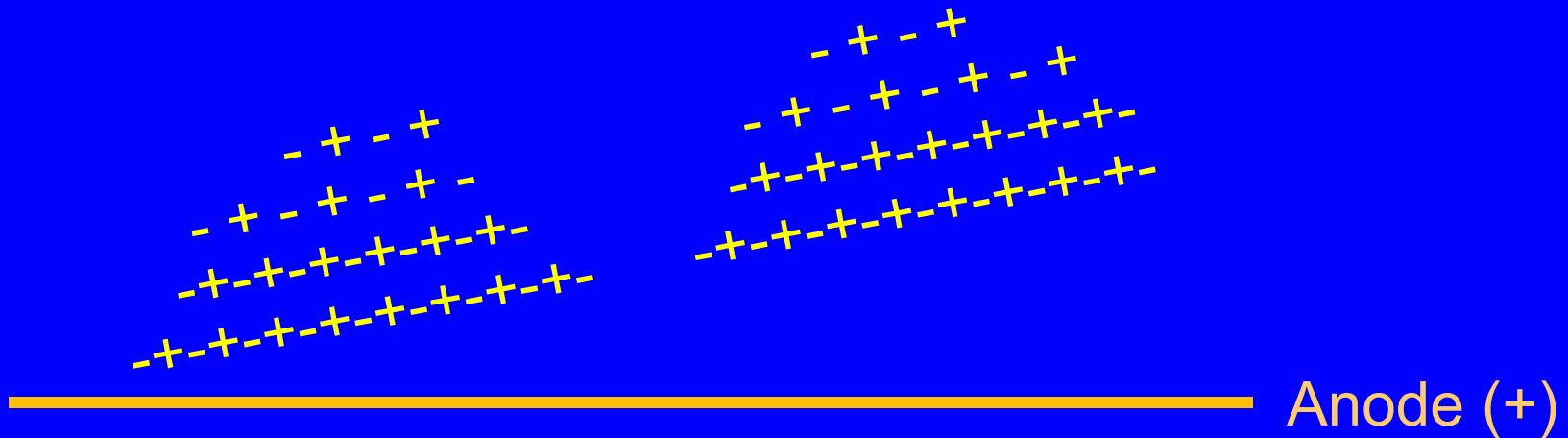
3. Proportional Region



————— Anode (+)

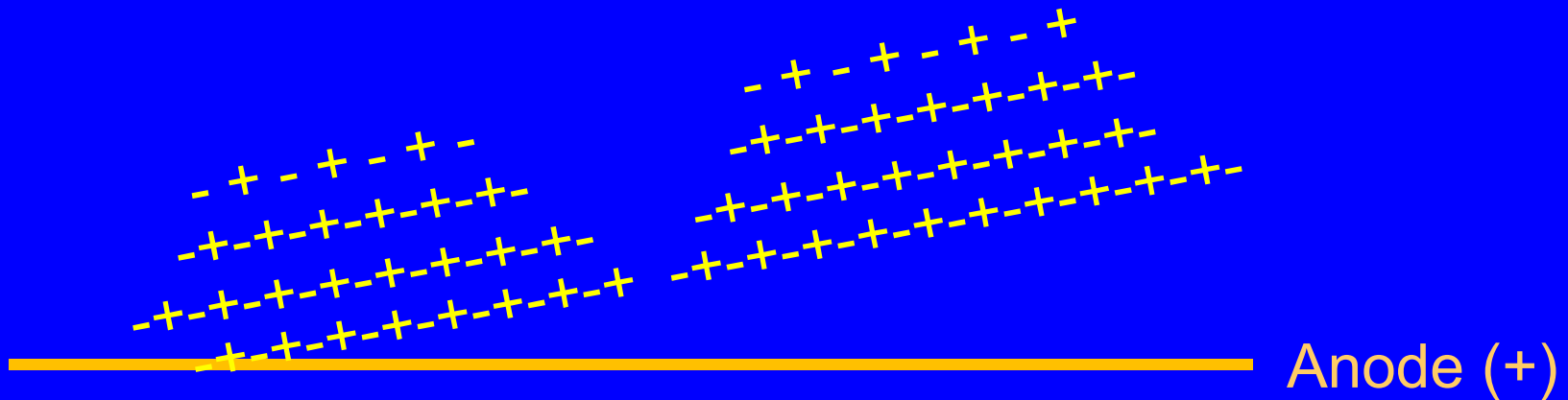
Six Region Curve

3. Proportional Region



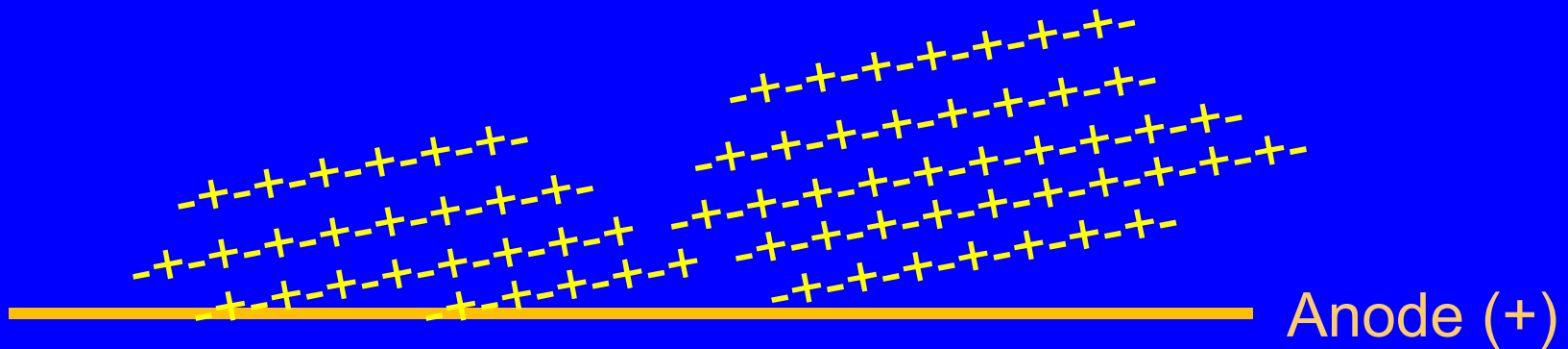
Six Region Curve

3. Proportional Region



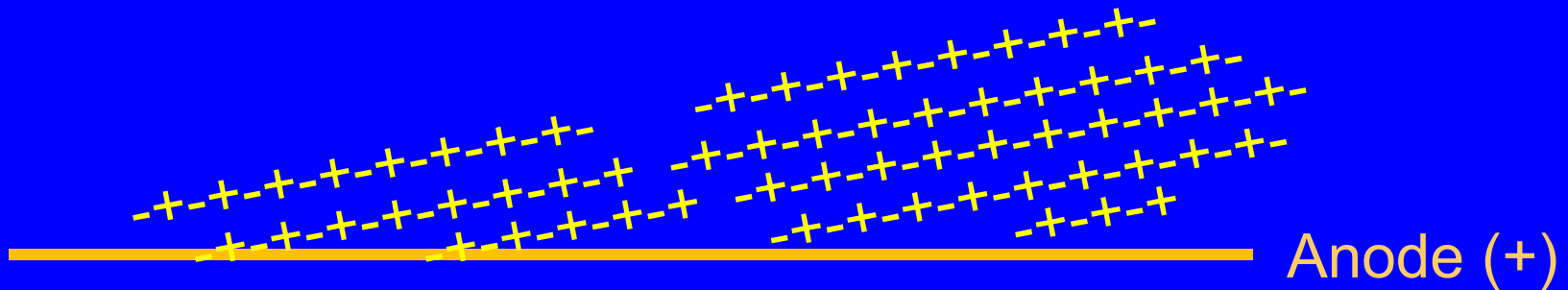
Six Region Curve

3. Proportional Region



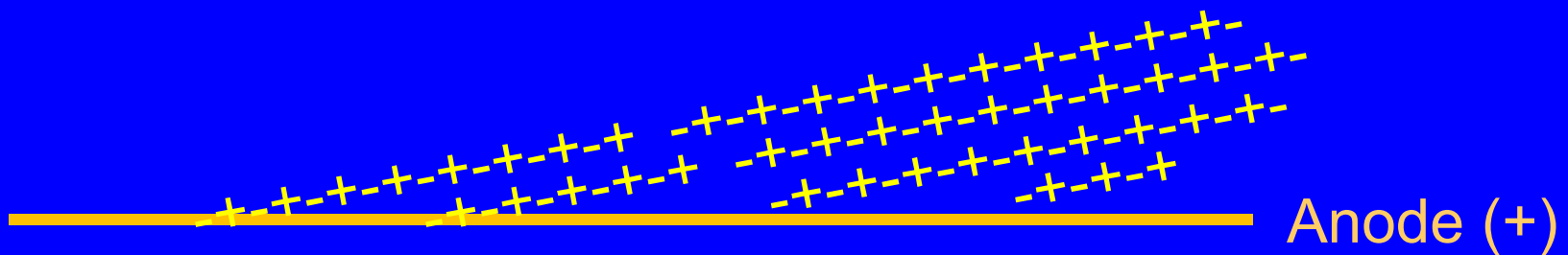
Six Region Curve

3. Proportional Region



Six Region Curve

3. Proportional Region



Six Region Curve

3. Proportional Region

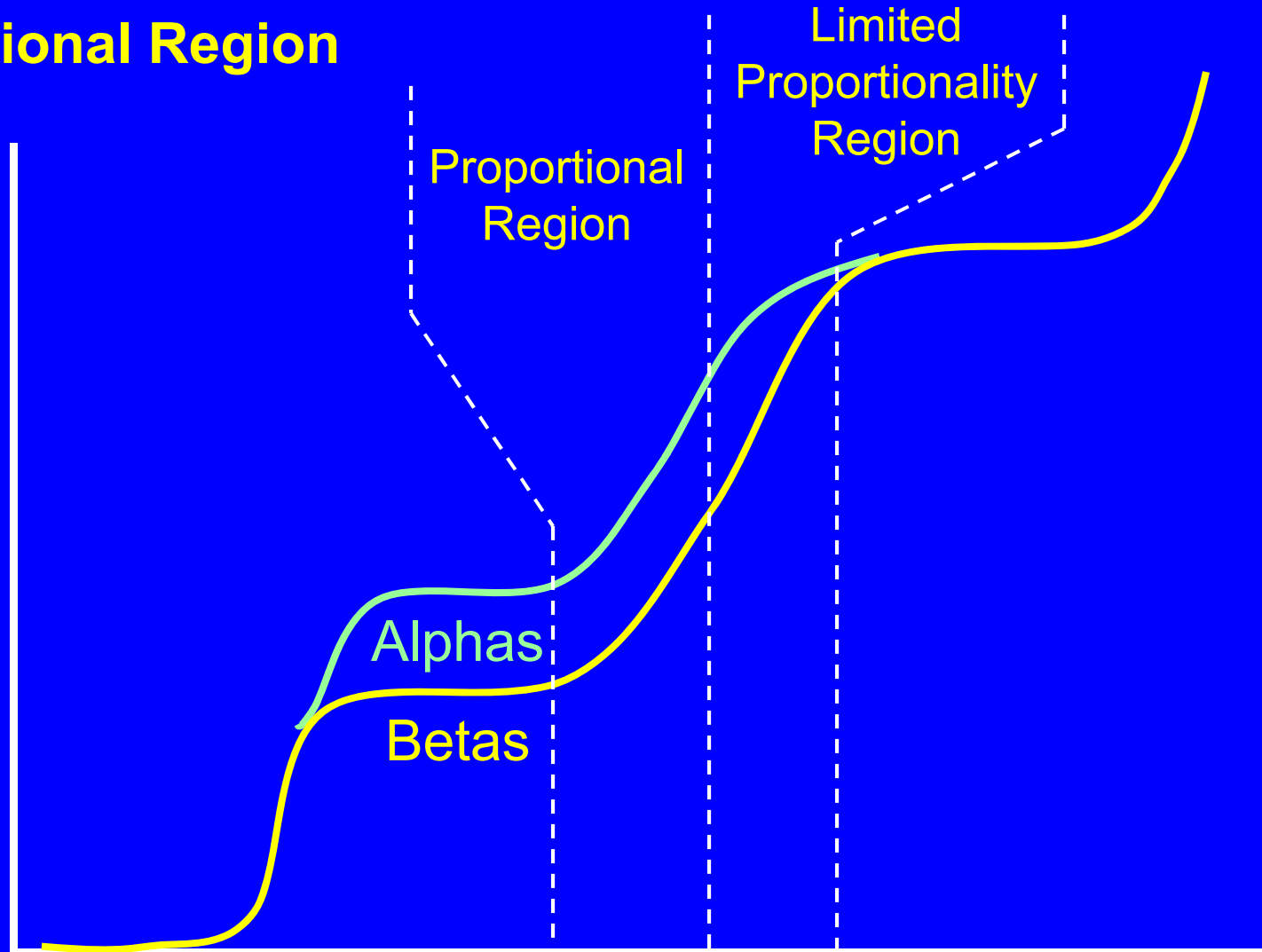
The voltage at which the electric field strength becomes large enough for avalanches to be produced marks the end of the ionization region and the beginning of the region of proportionality.

The proportional region is sometimes referred to as the region of true proportionality because there is a linear relationship between the number of primary ion pairs and the number of electrons reaching the anode.

Six Region Curve

3. Proportional Region

Pulse Height
(# electrons
collected at
anode)



Applied High Voltage

Six Region Curve

4. Region of Limited Proportionality

The high voltage and the multiplication factor are larger than in the proportional region.

What is now different is that pulse size is no longer linearly related to the number of primary ion pairs produced by the incident radiation. In other words, doubling the number of primary ion pairs, doesn't double the pulse size.

This increases the uncertainty of using pulse size to distinguish different types of radiation (e.g., beta vs. alpha).

Six Region Curve

5. Geiger-Mueller Region

In this region, the size of the pulse is totally independent of the number of primary ion pairs produced by the incident radiation.

In other words, alpha particles, beta particles and photons produce pulses of exactly the same size.

There is a complete loss of proportionality between the radiation energy deposited in the detector gas and the pulse size.

Six Region Curve

5. Geiger-Mueller Region

At the high voltages associated with the Geiger-Mueller Region, the avalanche spreads along the complete length of the anode.

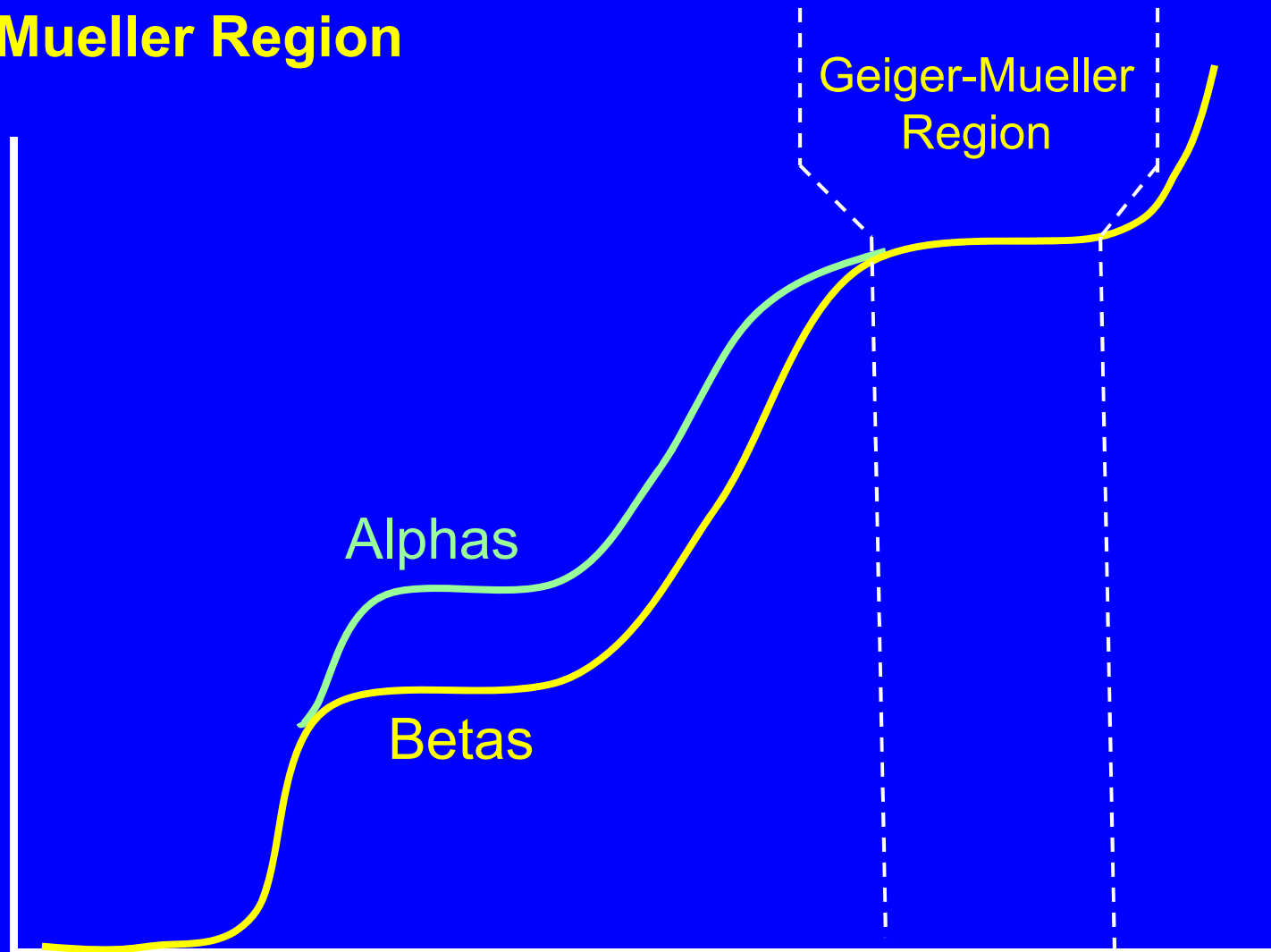
The pulse shuts itself down when the accumulation of positive ions around the anode reduces the strength of the electric field below that required for continued propagation.

At a given voltage in the Geiger region, the size of the pulse is the same no matter how many primary ion pairs were produced by the incident radiation.

Six Region Curve

5. Geiger-Mueller Region

Pulse Height
(# electrons
collected at
anode)



Applied High Voltage

Six Region Curve

5. Geiger-Mueller Region

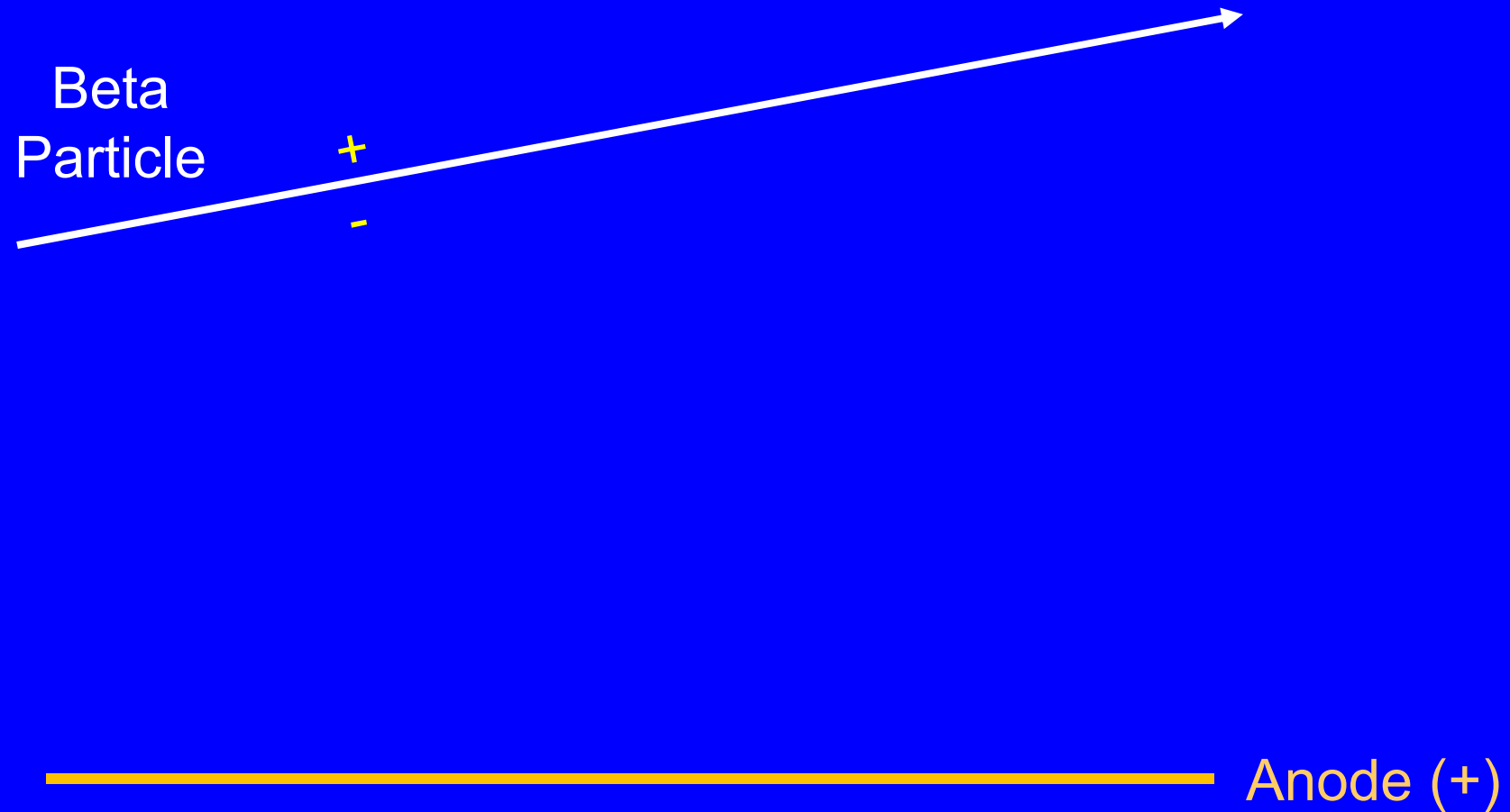
Why does the avalanche spread along the anode? Because avalanches not only involve ionization, they also involve the excitation of gas molecules. And when excited molecules in an avalanche de-excite, they can emit UV photons.

In the Geiger-Mueller region enough UV photons are produced for some to be absorbed by the gas molecules via the photoelectric effect. This leads to further ionization of the gas and the creation of additional avalanches. By this means, a single avalanche becomes thousands of avalanches.

The gases used in GM tubes are selected to promote this generation and absorption of UV photons.

Six Region Curve

5. Geiger-Mueller Region



Six Region Curve

5. Geiger-Mueller Region

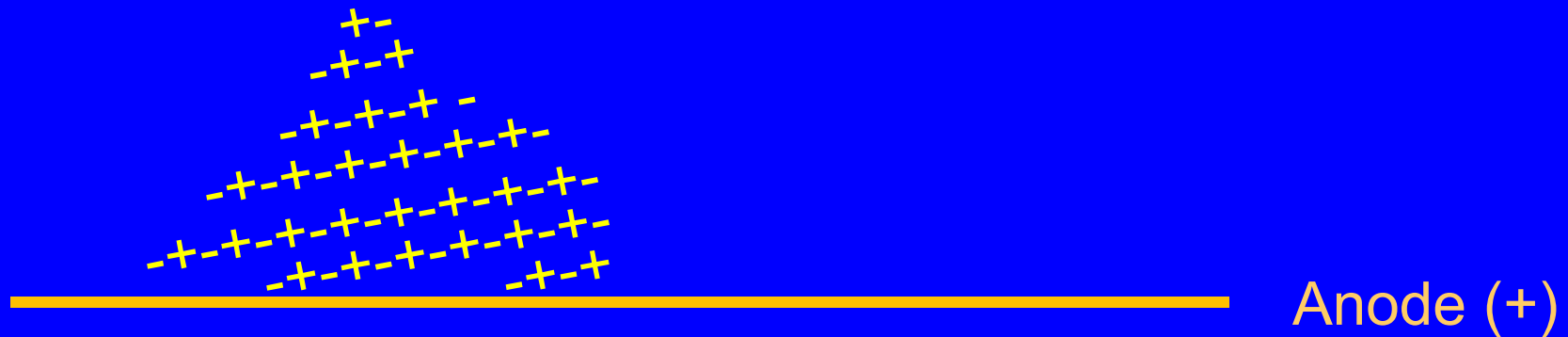
+

-

————— Anode (+)

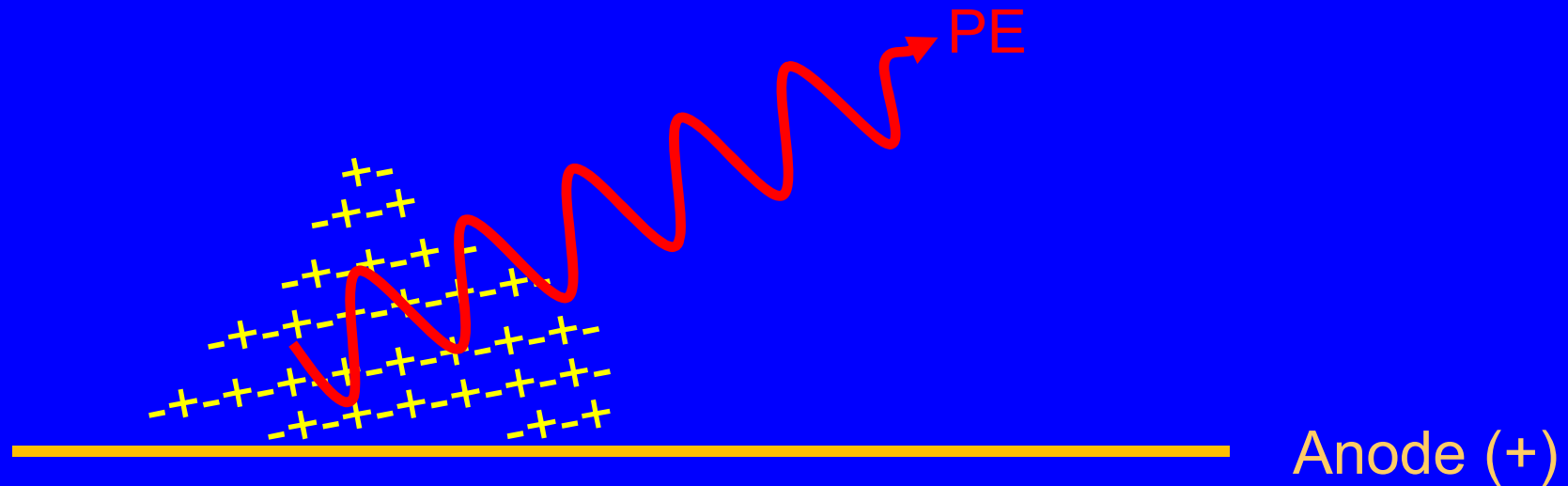
Six Region Curve

5. Geiger-Mueller Region



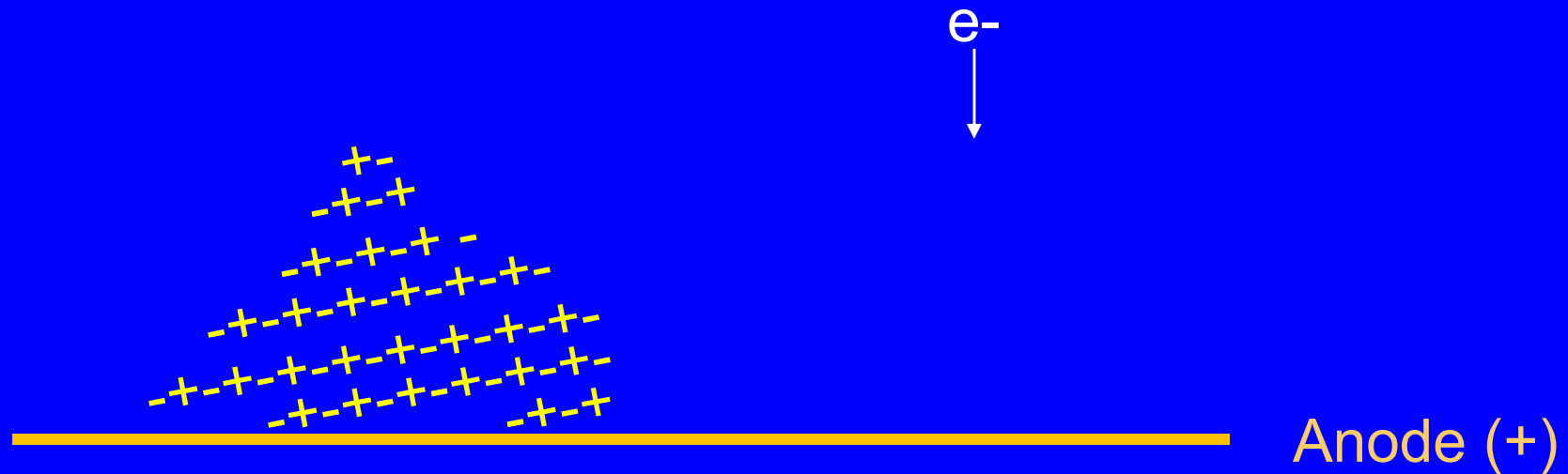
Six Region Curve

5. Geiger-Mueller Region



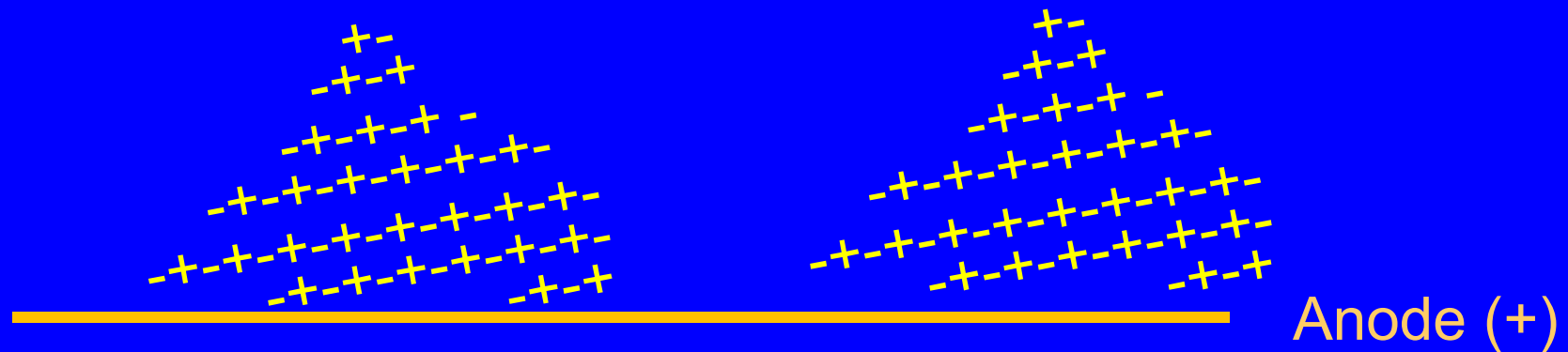
Six Region Curve

5. Geiger-Mueller Region



Six Region Curve

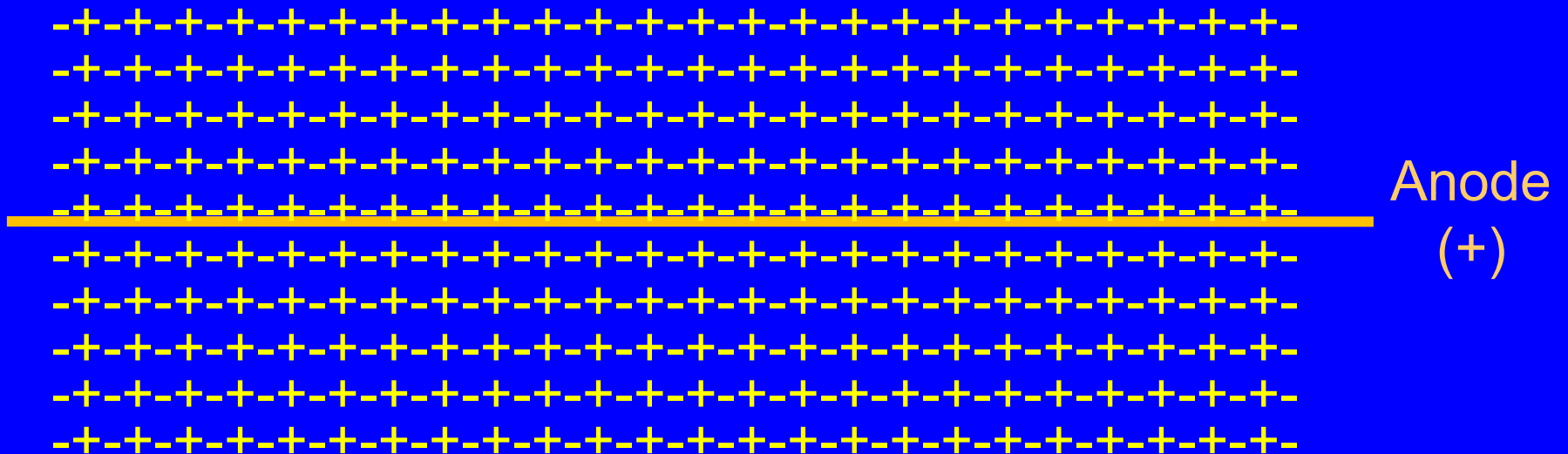
5. Geiger-Mueller Region



Six Region Curve

5. Geiger-Mueller Region

The result:



The avalanche completely envelops the anode.

Six Region Curve

5. Geiger-Mueller Region

The electrons in the avalanche are collected quickly, but not the positive ions.

This creates a positive “space” charge in the vicinity of the anode.

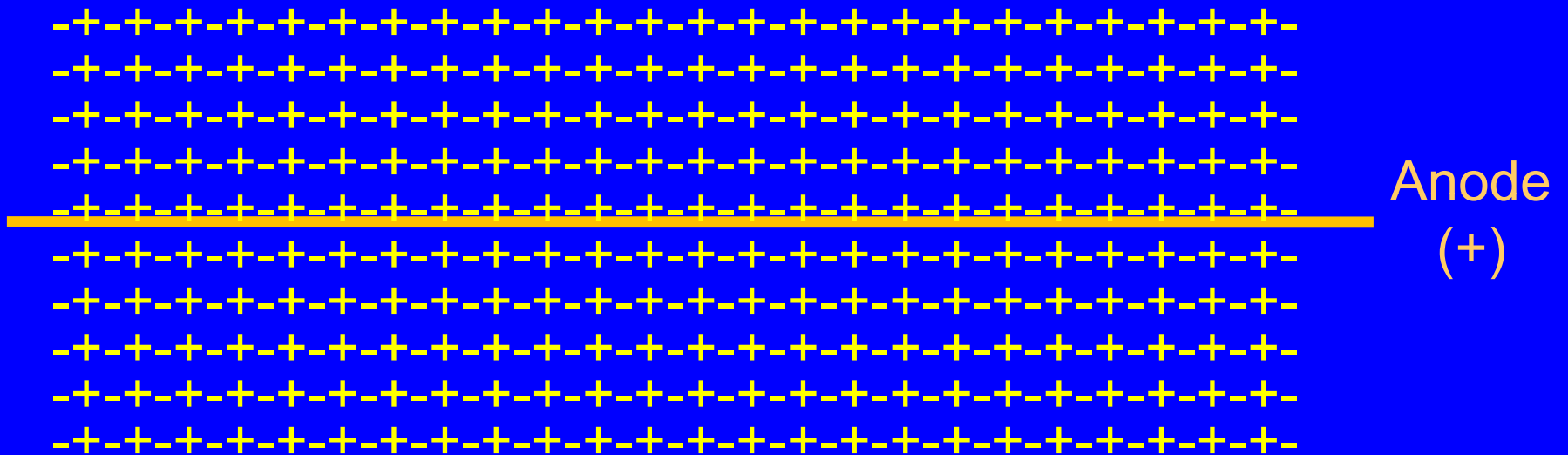
This positive charge reduces the strength of the electric field near the anode.

The reduced electric field strength shuts down the pulse since further ionization is impossible.

Six Region Curve

5. Geiger-Mueller Region

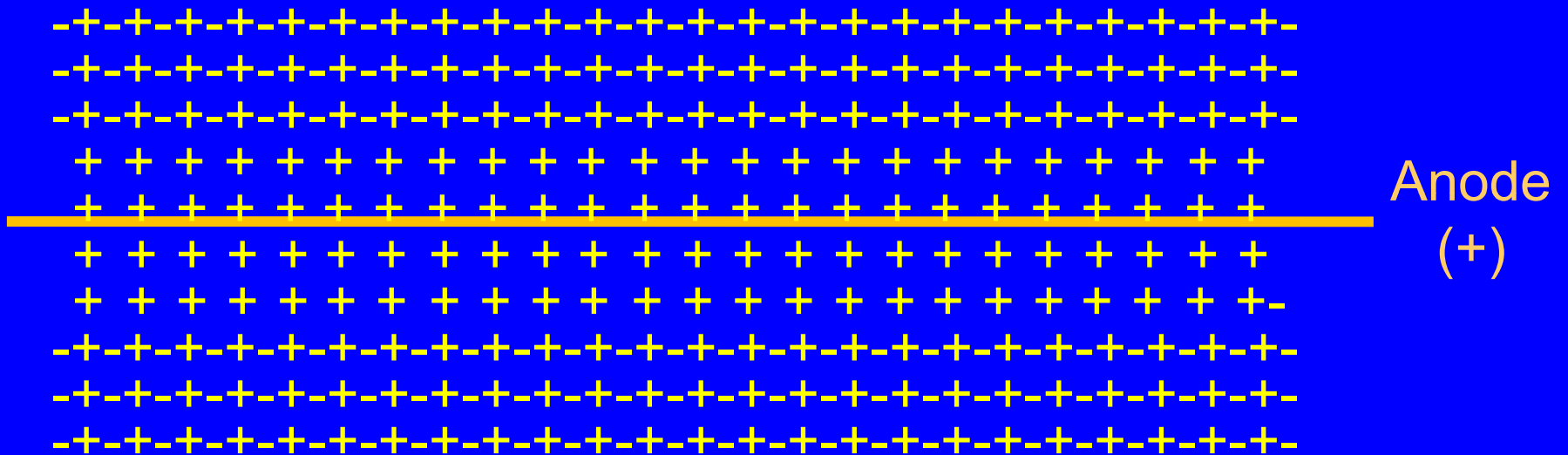
The result:



The avalanche completely envelops the anode.

Six Region Curve

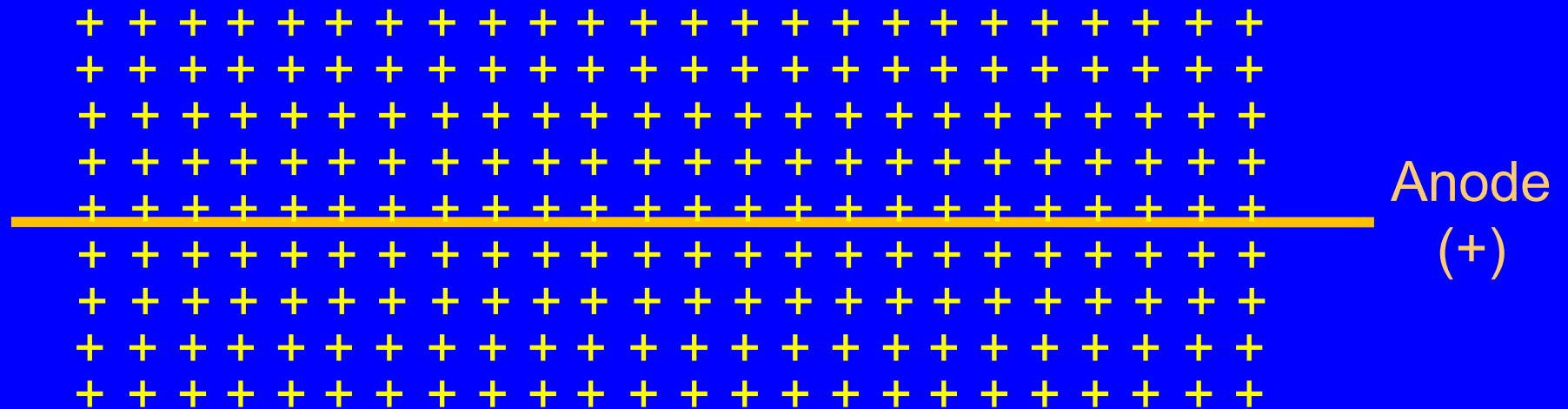
5. Geiger-Mueller Region



The electrons are collected quickly, but not the positive ions.

Six Region Curve

5. Geiger-Mueller Region



This positive charge reduces the strength of the electric field near the anode which shuts down the pulse. Further ionization is impossible.

Six Region Curve

5. Geiger-Mueller Region

In the Geiger-Mueller region, the plateau still slopes upwards.

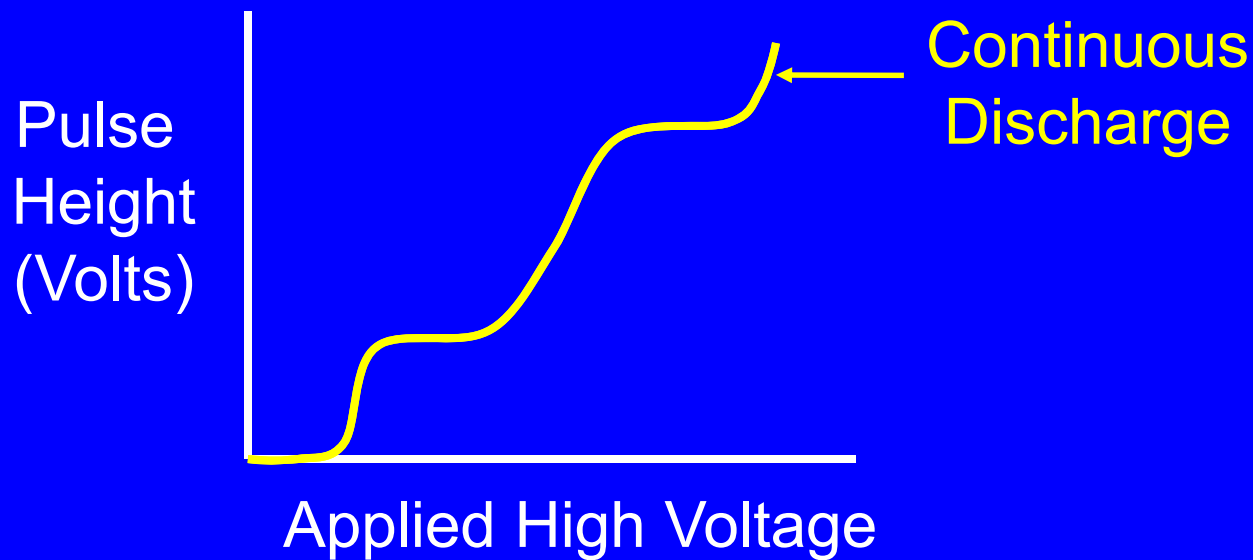
As the high voltage increases on the plateau, it takes more positive ions to produce a large enough space charge to overcome the increased field strength.

Six Region Curve

6. Continuous Discharge

In this region, arcing will occur that can result in a complete breakdown of the gas.

Any extended operation in this region will destroy the tube.



Six Region Curve

Where the Avalanche Occurs

We want all the avalanches to be produced within a small volume around the anode, i.e., within a fraction of a millimeter.

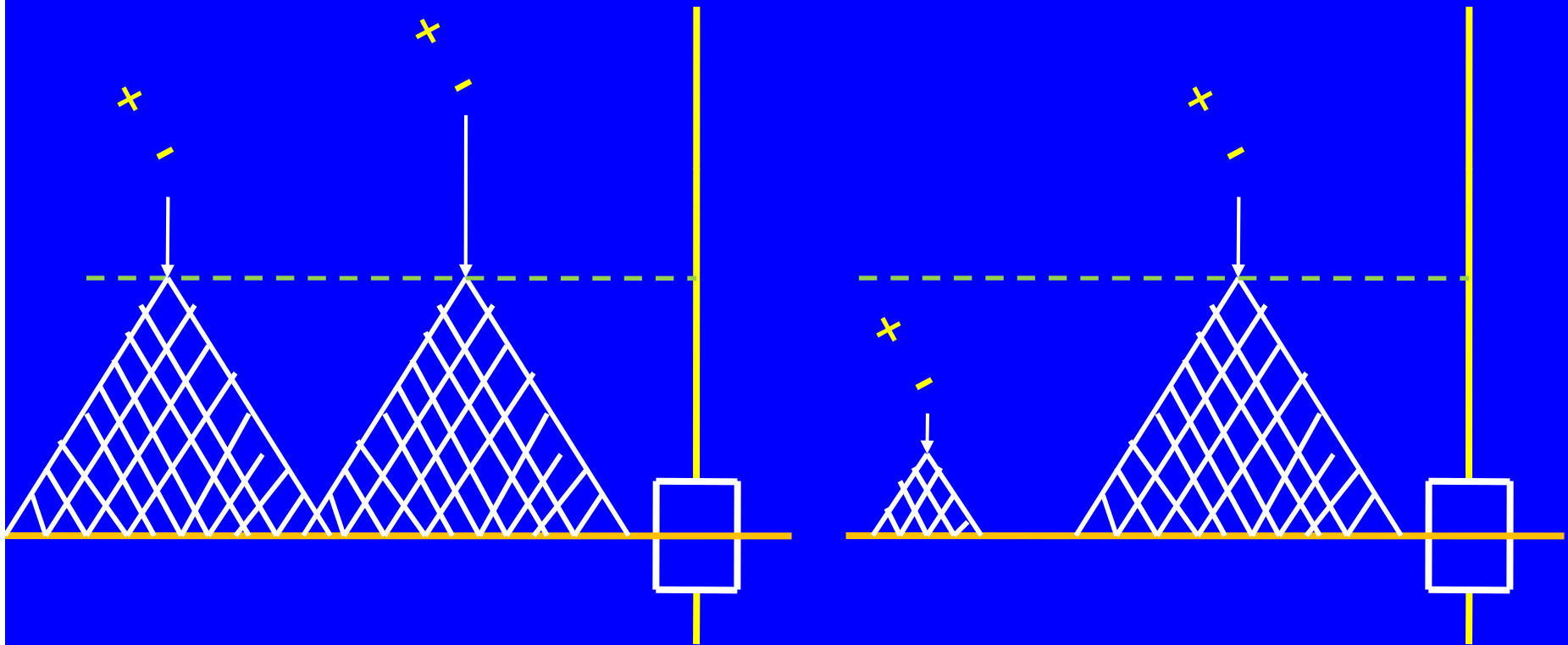
This way, the primary ion pairs produced by the radiation will be created outside the region in which the avalanche is produced. This is necessary if the pulse size is to reflect the energy deposited in the gas.

If primary ion pairs were produced inside the avalanche region, their avalanches would be smaller than those produced by primary ion pairs formed outside this region. This is because the avalanches would begin closer to the anode.

Six Region Curve

Where the Avalanche Occurs

This figure shows the effect of primary ion pair being formed inside the region where the avalanche occurs.

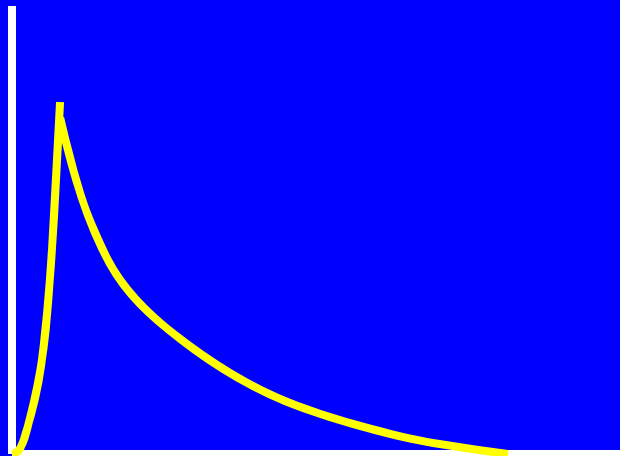


The pulse on the right is smaller than it should be.

Know the Difference
Between these Curves

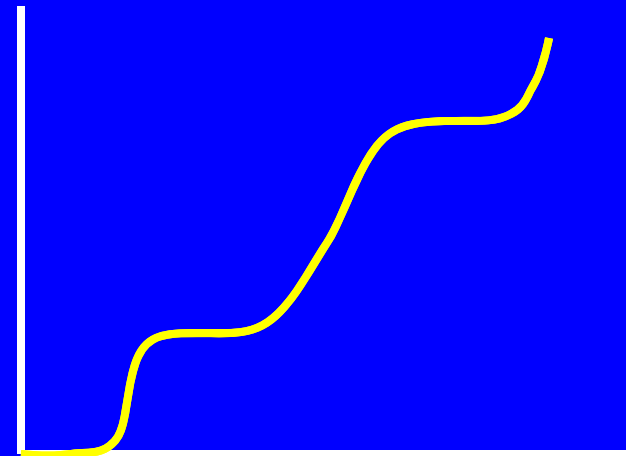
Know the Difference Between these Curves

Pulse Height (Volts)



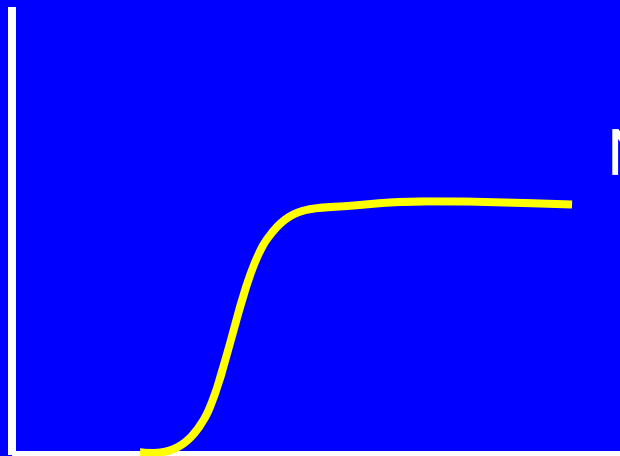
Time

Pulse Height (Volts)



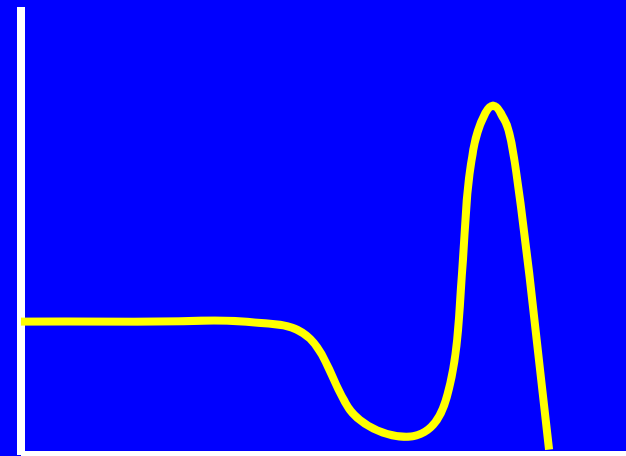
Applied High Voltage

Number Of Pulses



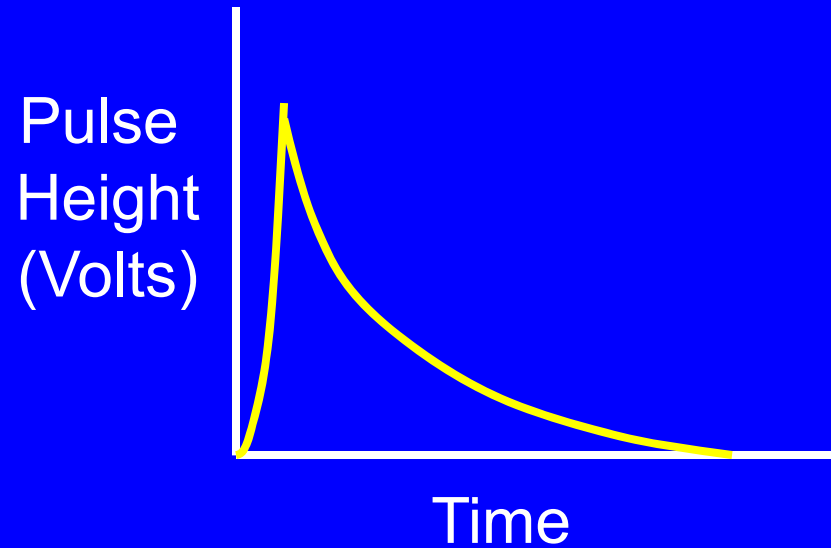
Applied High Voltage

Number Of Pulses



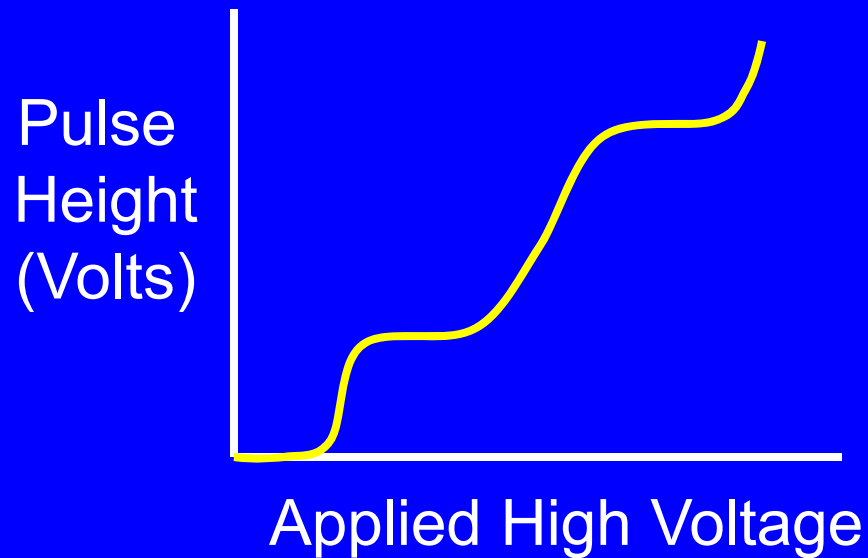
Pulse Height

Know the Difference Between these Curves



This is a single pulse, more or less as might be seen with an oscilloscope.

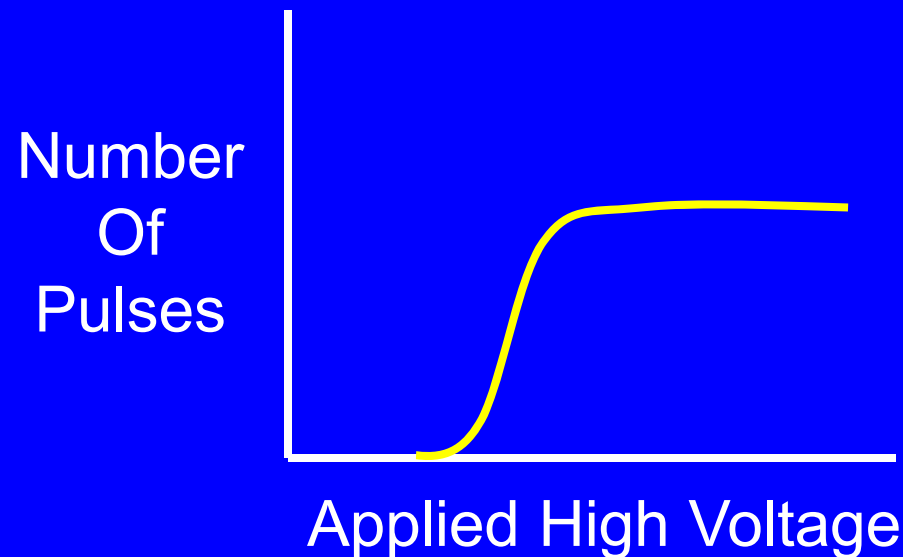
Know the Difference Between these Curves



This is the five/six region curve.

Is used to help explain the difference between ionization chambers, proportional counters and Geiger Mueller detectors.

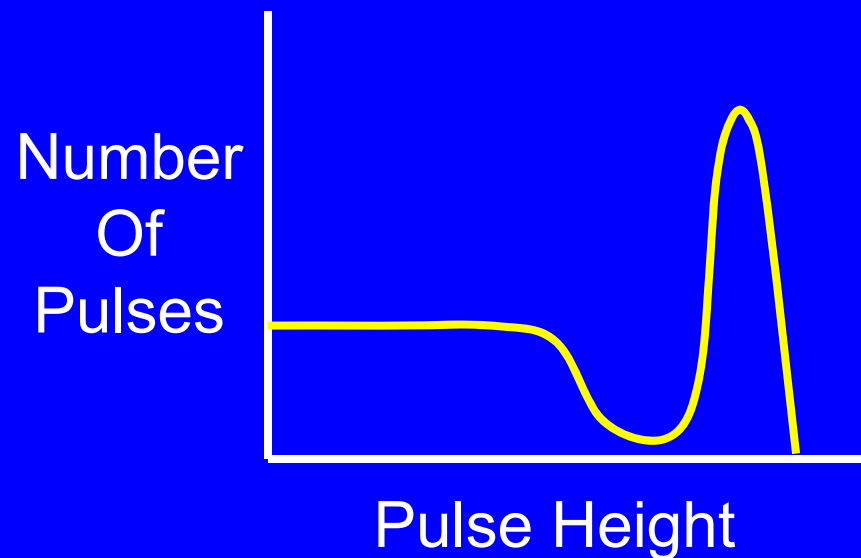
Know the Difference Between these Curves



This is a sometimes known as a characteristic curve.

It is produced to help determine the appropriate operating voltage for a gas detector. They are occasionally generated for scintillation detectors as well.

Know the Difference Between these Curves



This is a spectrum.

The peaks on the spectrum are formed by many pulses of similar height. The pulse height associated with the peak identifies the energy of the radiation (gamma or alpha). The number of counts in the peak (peak area) is related to the activity of the source.

Basic Characteristics of Gas Detectors

Basic Characteristics of Gas Detectors

Ion Chambers

- operate in the ionization region
- can use both parallel plate and coaxial electrodes
- usually operate in the current mode
- primarily used to measure exposure rates due to gamma rays and x-rays
- usually poor response at low exposure rates (< 1 mR/hr)
- capable of measuring high exposure rates (1–1000 R/hr)
- energy independent (flat relative response curve)
- air often used as the fill gas
- might be sealed or open to the atmosphere
- if open to atmosphere: they use a desiccant (silica gel) to dry the air; their response is affected by ambient pressure and temperature

Basic Characteristics of Gas Detectors

Proportional Counters

- operate in the proportional/limited proportionality region
- use coaxial electrodes or variant
- almost always operate in the pulse mode
- primarily used to count alpha and beta sources and surface contamination
- can distinguish small beta pulses from larger alpha pulses
- much shorter dead time than GMs, therefore better at high count rates
- might be sealed or operate in gas flow mode
- gas flow mode allows operation at one atmosphere and the use of larger and thinner window which improves efficiency
- P-10 is common fill gas: 90% argon and 10% methane

Basic Characteristics of Gas Detectors

Geiger-Mueller Detectors

- operate in the Geiger Mueller region
- use coaxial electrodes
- usually operate in the pulse mode
- used to measure exposure rates or count beta sources and surface contamination
- exposure rate measurements ca. 0.1 mR/hr to 1 R/hr
- energy dependent: when measuring exposure rate they over respond at low photon energies (ca. < 200 keV)
- all pulses are the same size, hence no discrimination between alpha and beta and gamma pulses.
- usually sealed with gas at a fraction of an atmosphere
- neon fill gas with halogen (Cl_2) quench gas is common
- sometimes helium fill gas with organic quench gas
- large dead times (e.g., 100 μs)