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IVD. Detectors

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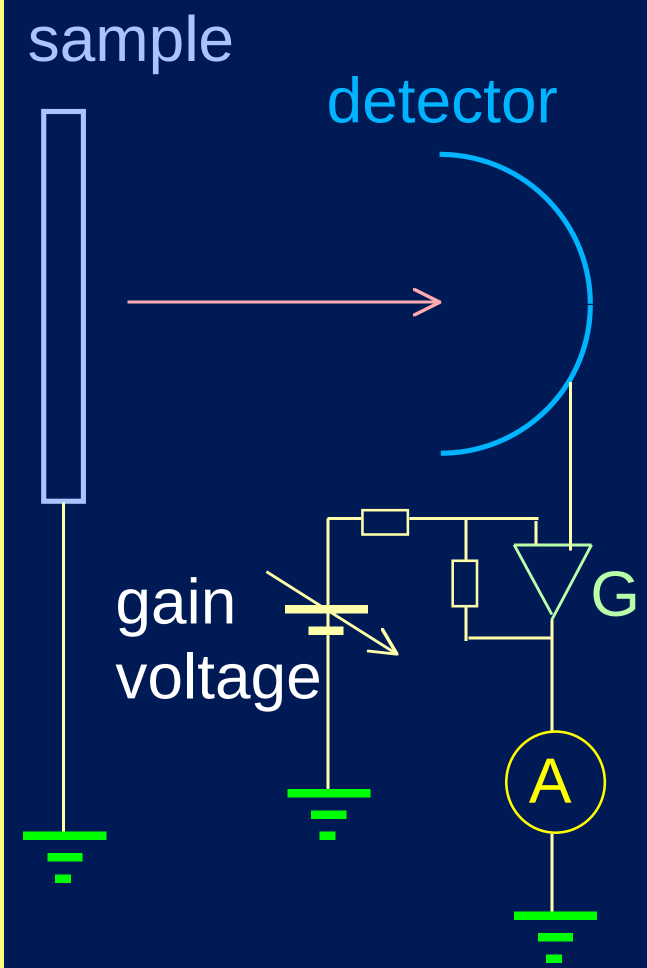
Principles

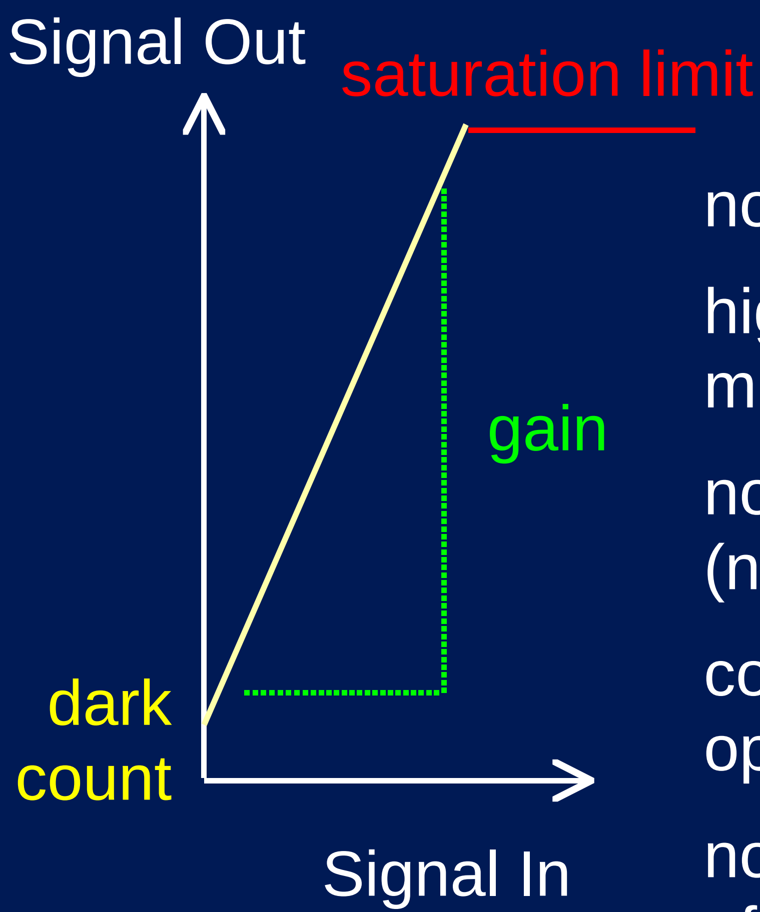


The detector should count the number of electrons that arise from the event.

This is a current that could be detected by a current meter (amp meter A).

Because the current flow from AES and XPS events is typically very small, we usually build a signal amplification component (gain G) into the detector circuit.

Goals



The ideal signal detector (with amplifier) will have

no zero count (no dark count)

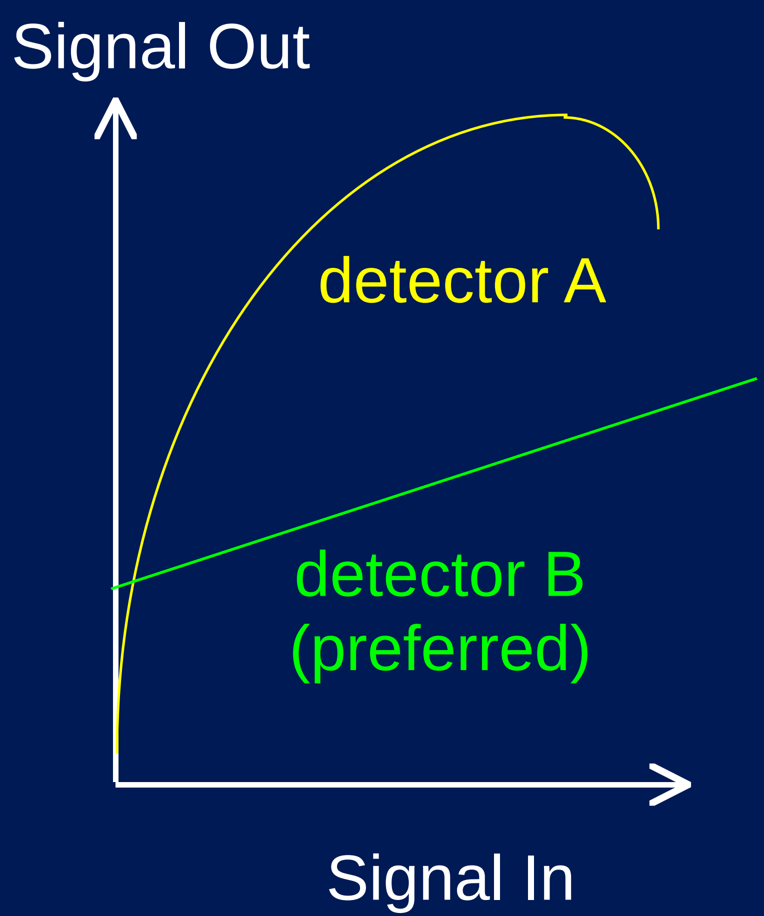
high gain (high signal multiplication)

no limit to the operation range (no saturation limit)

constant gain over the entire operation range

no noise (gain is independent of time)

Limitations



In practice, the response of the detector can exhibit non-idealities. The most common are

measurable dark count

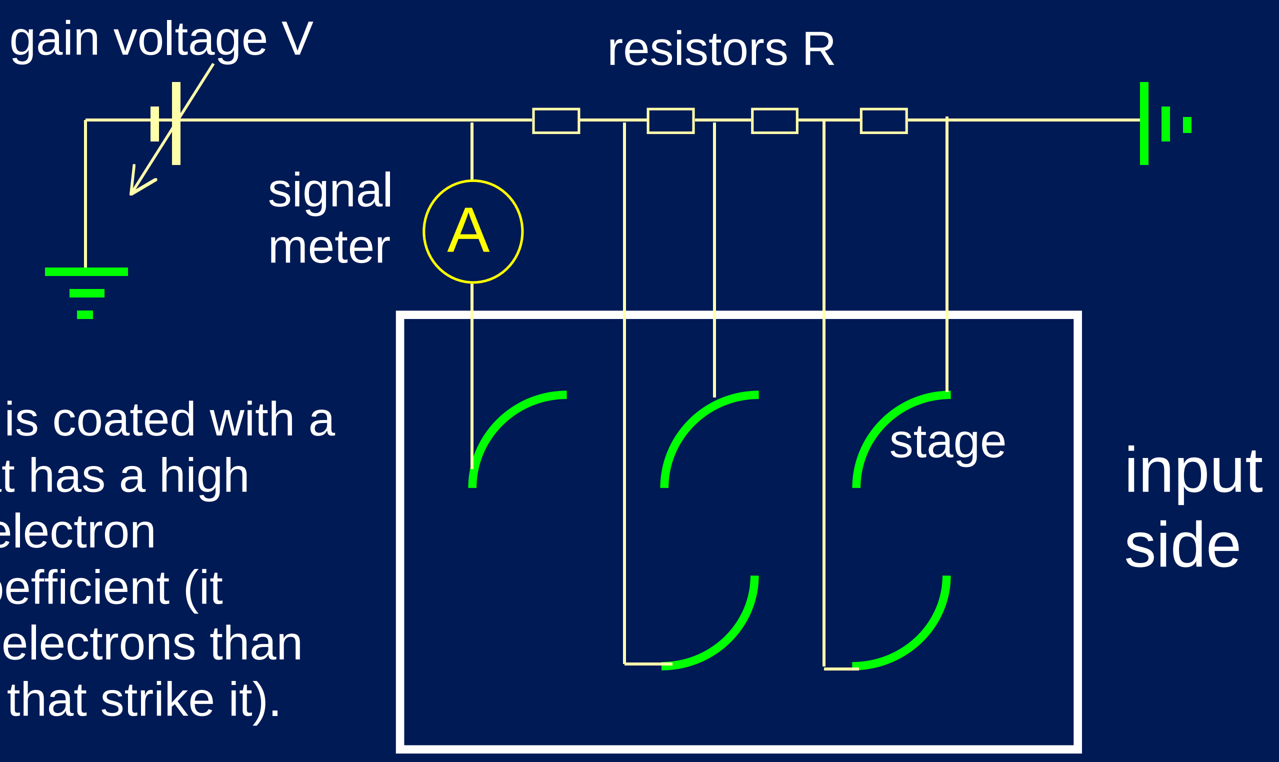
clear saturation limit

non-zero noise level

Most detectors are designed to be linear (have a constant gain over the operating range), even though the gain may be lower and the dark count higher than what could be obtained otherwise.

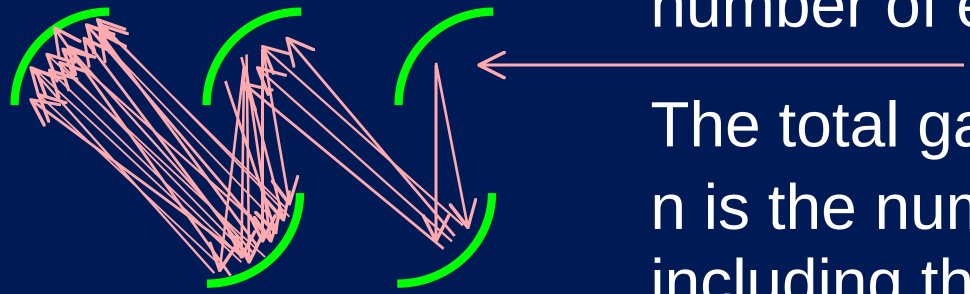
Design

The electron multiplier has a number of stages that operate at increasingly greater (positive) voltages. The signal is the current flow at the last stage.



Each stage is coated with a material that has a high secondary electron emission coefficient (it emits more electrons than the number that strike it).

Principles and Parameters



Each stage mutliples the number of electrons by g.

The total gain, G, is g^n, where n is the number of stages not including the first (the schematic shows g = 2 with n = 4, so G = 16).

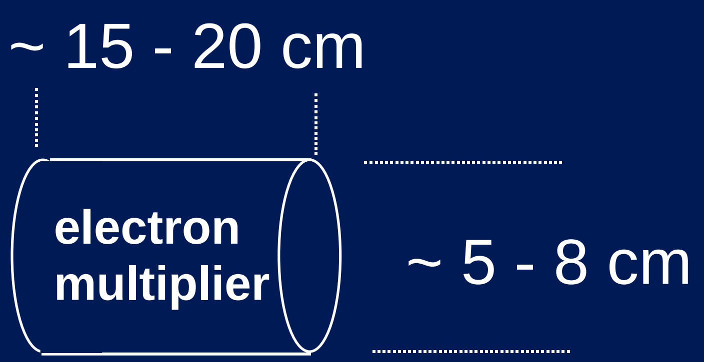
Typical Values

V ~ 3 - 5 kV

R ~ MΩ ranges

n ~ 5 - 12

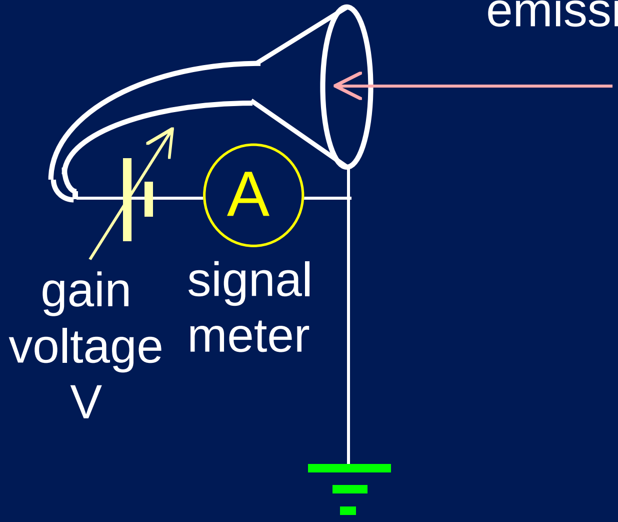
G ~ $10^3 - 10^6$



Channeltron

The channeltron compacts the design of the electron multiplier into a single component shaped like a cornicopia.

The inside of the channeltron is coated with a material that has a high secondary electron emission coefficient.



Typical Values

~ 5 cm long

V ~ 2 - 4 kV

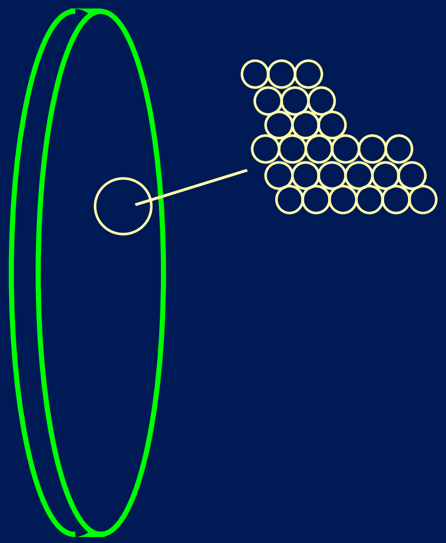
G ~ 10^3 - 10^5

Design

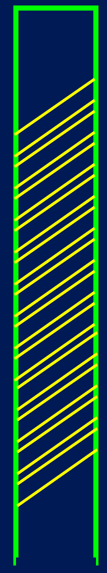
close packed array of hollow ceramic fibers

draw down the fibers

cut plate at slight angle

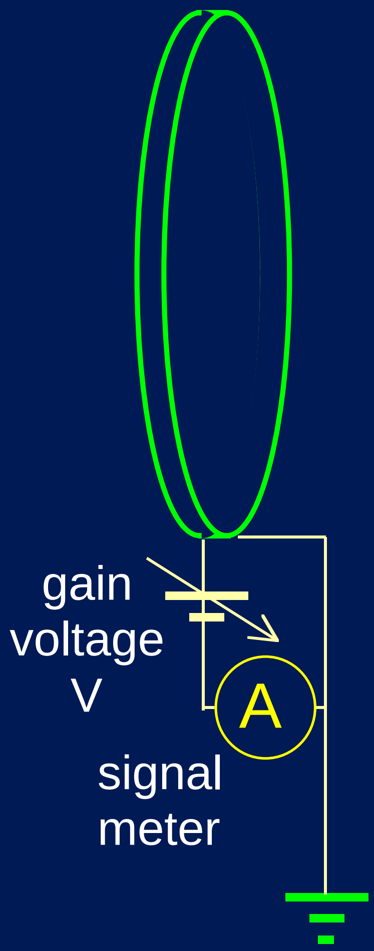


The channelplate has an array of close packed holes that are at a slight angle (so that electrons do not just shoot straight through).



front side

Principles and Parameters



The gain voltage applied between the front and rear faces.

Typical Values

~ 5 - 10 cm diameter

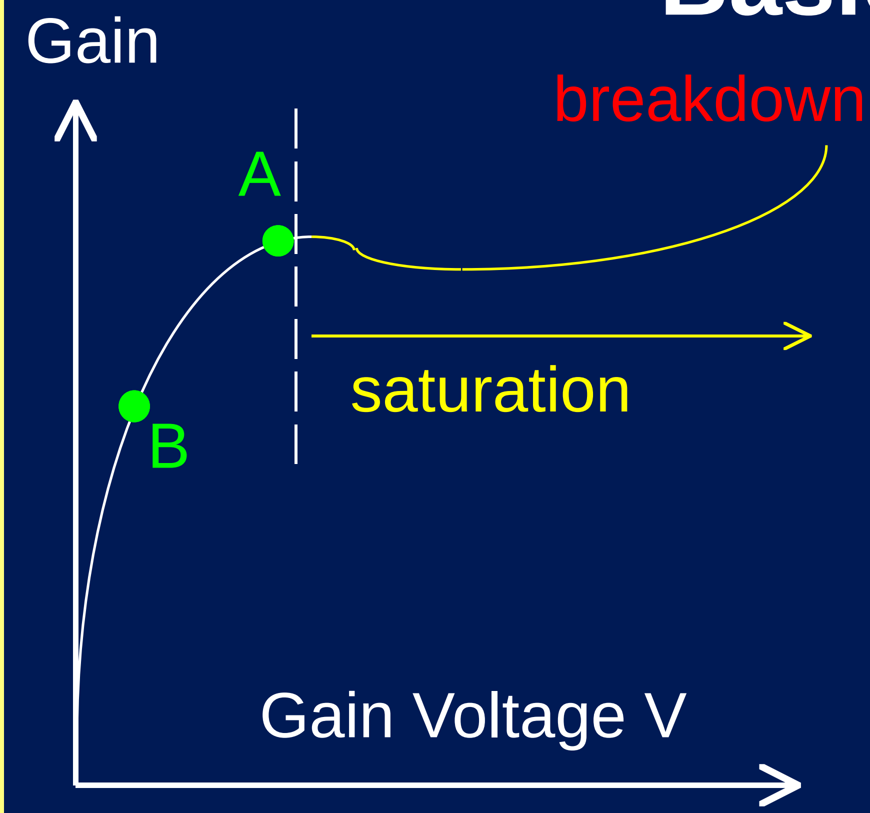
~ 2 - 3 mm thick

~ 10 - 100 micron sized holes

V ~ 2 - 4 kV

G ~ 10^3 - 10^5

Basics



Most electron detectors show this type of response curve.

For signal counting, we operate at V just below saturation (point A).

For dN/dE operations, we may operate at lower V (point B).

The operating voltage we need to use will increase as a function of time until the detector dies.

Comparison

Electron Multiplier

Pros

readily available for all types of particles and photons

highest gains possible

Cons

sensitive to oxidation

Channeltron

Pros

compact in size

Channelplate

Pros

compact in size

Utility

The typical instruments today are divided in their use of analyzers and detectors (EM - electron multiplier, CT - channeltron, CP - channel plates).

AES

analyzer RFA
detector ampmeter

analyzer CMA, HSA
detector EM, CT

XPS

analyzer CMA
(less common)
detector EM, CT

analyzer HSA
detector EM, CT, CP