SERC School on EHEP

# Proportional Counter

Batch-1,Group G3
Anil Kumar, TIFR Mumbai
Anjali Sharma, PU, Chandigarh
Asar Ahmed, University of Delhi, Delhi
Mitali Mondal, VECC, Kolkata
Shubham Pandey, IISER, Pune

# AIM OF OUR STUDY

To know about basic physics of Gas detectors and study of general characteristics of Proportional Counter.

# Interaction of Radiation with Matter

- Charged Particles

  **Electron, Muon, Alpha Particle etc:**

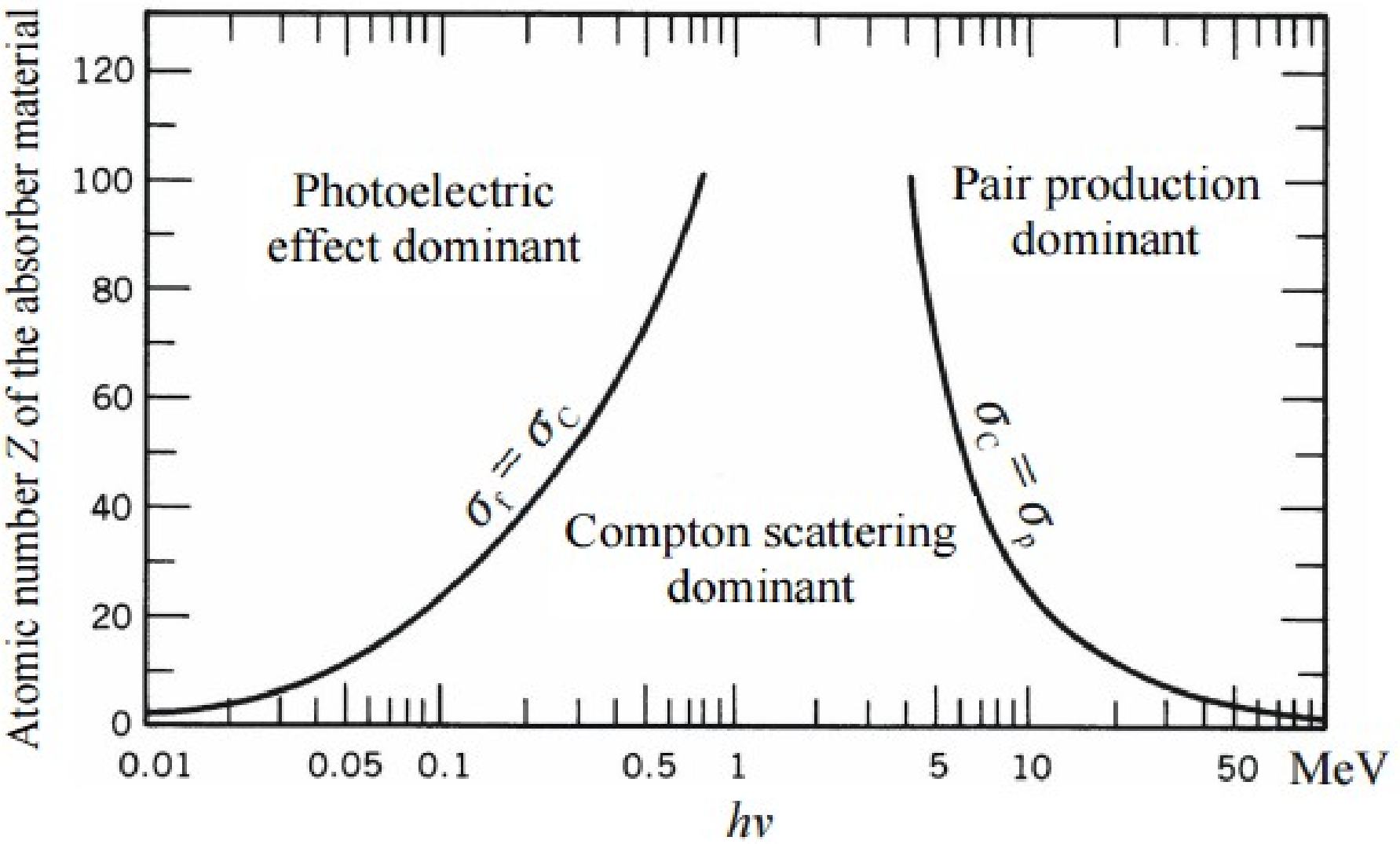
  Ionization, Excitation, Cherenkov, Bremsstrahlung...

- Neutral Particles

  **Photon :** Photoelectric Effect, Compton Scattering, Pair Production.

  **Neutron:** Nuclear Reaction, Scattering with Nuclei...

# Processes at different Energy Ranges for different Absorber Material :




In our case, we have used Argon (Z=18) and X-Ray source $^{55}Fe$ (E ~ 5.9keV)

Image Source: Techniques for Nuclear and Particle Physics Experiments – William R.Leo

# *Practical Gaseous Ionisation Detection Regions*

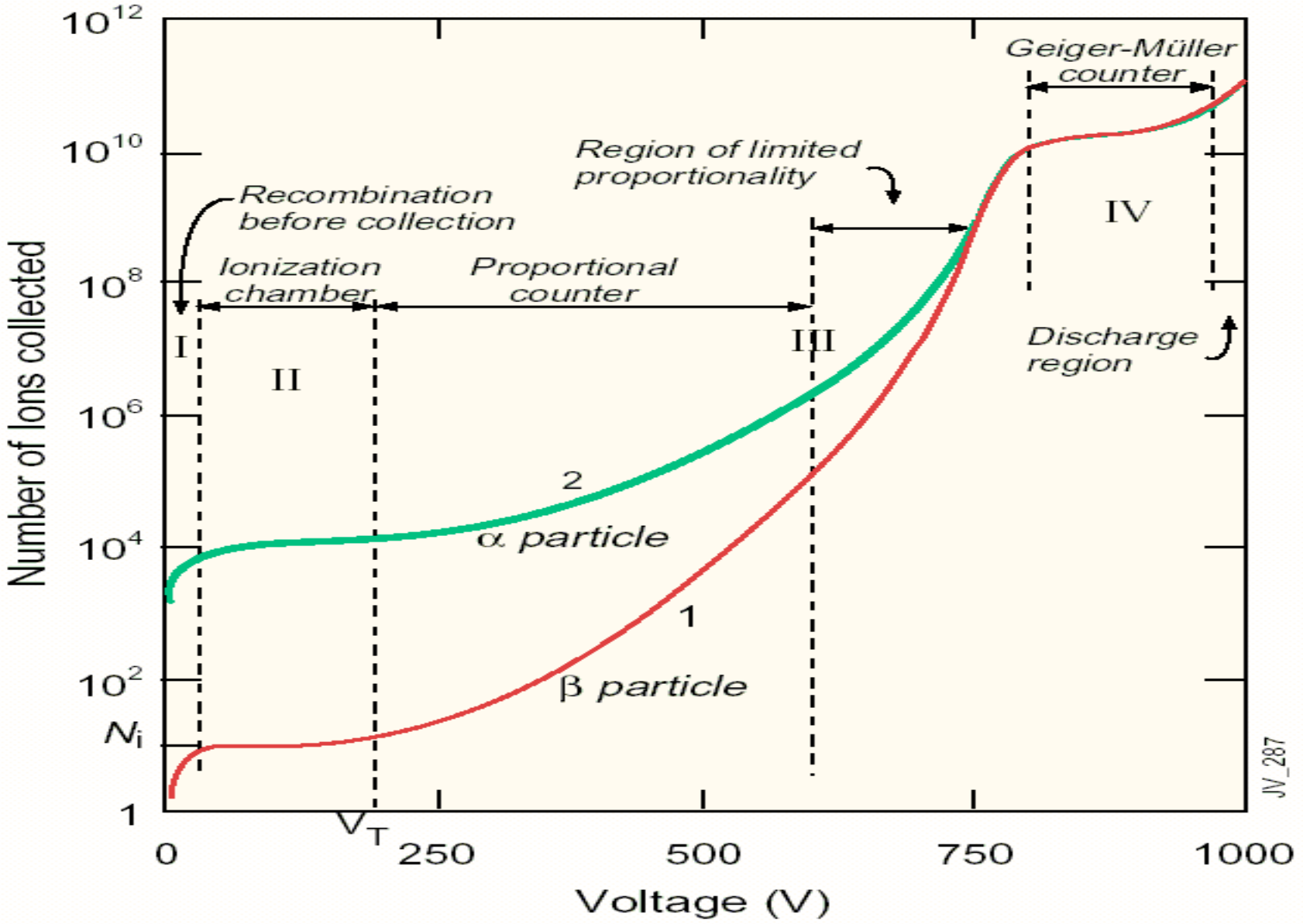



Image source: https://www.slideserve.com/cheung/ionization-detectors

# *Schematic Diagram of Proportional Counter :*

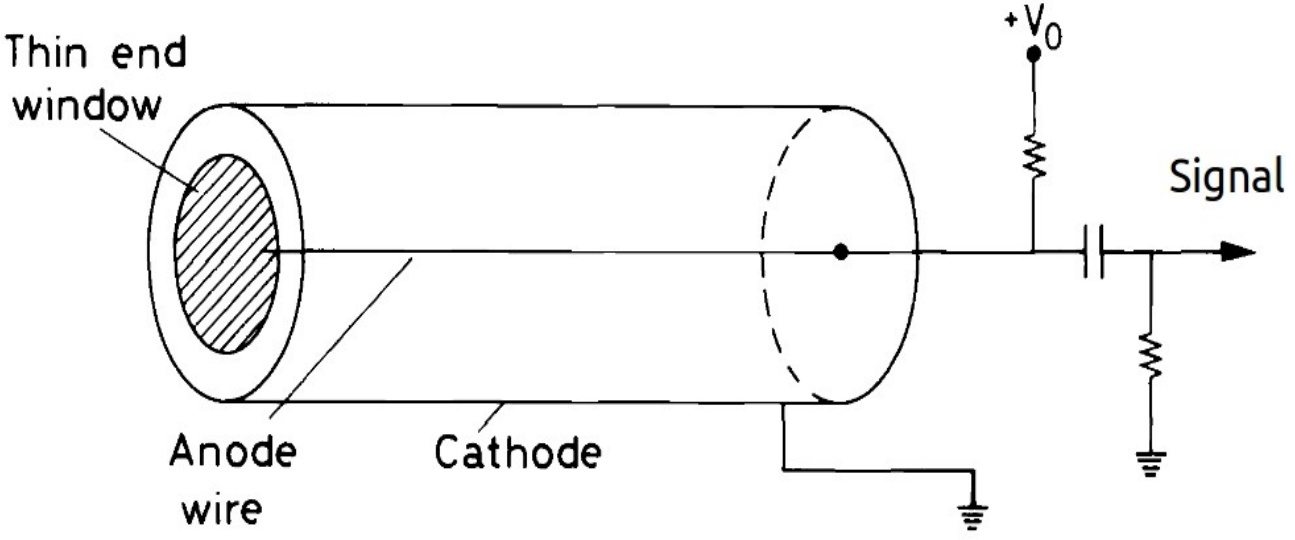
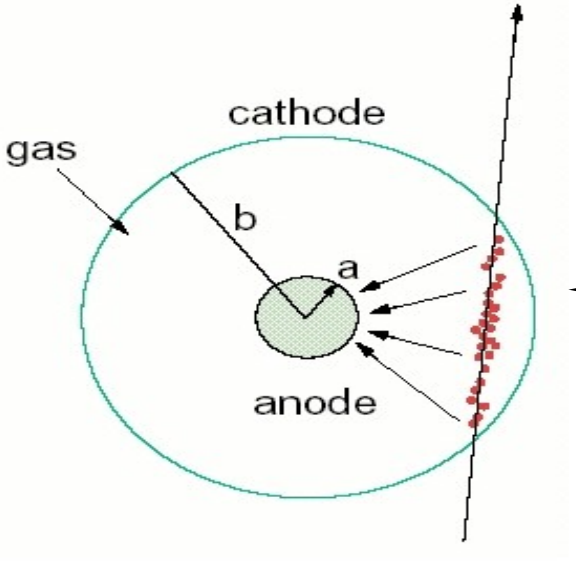


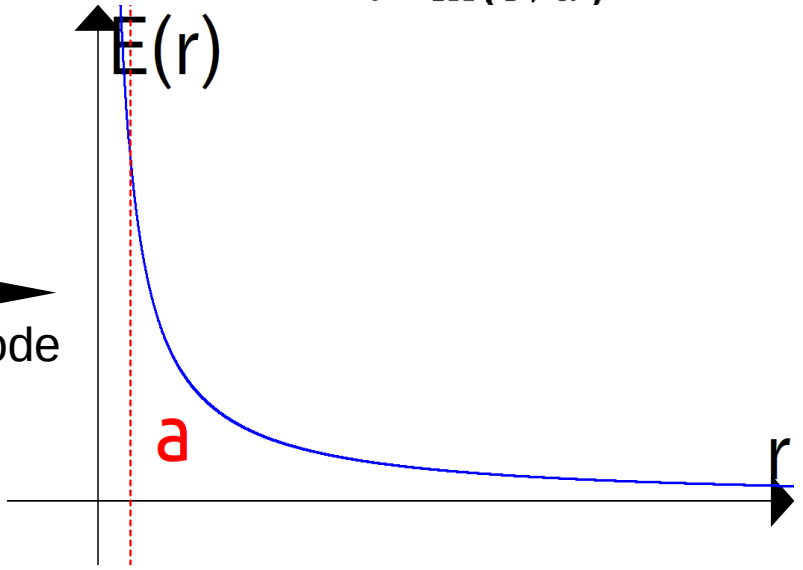

Image Source: Techniques for Nuclear and Particle Physics Experiments – William R.Leo

$$E = \frac{1}{r}\frac{V_0}{\ln(b/a)}$$




Variation of Electric Field

Along radial distance from anode wire



# *Time Development of an Avalanche*

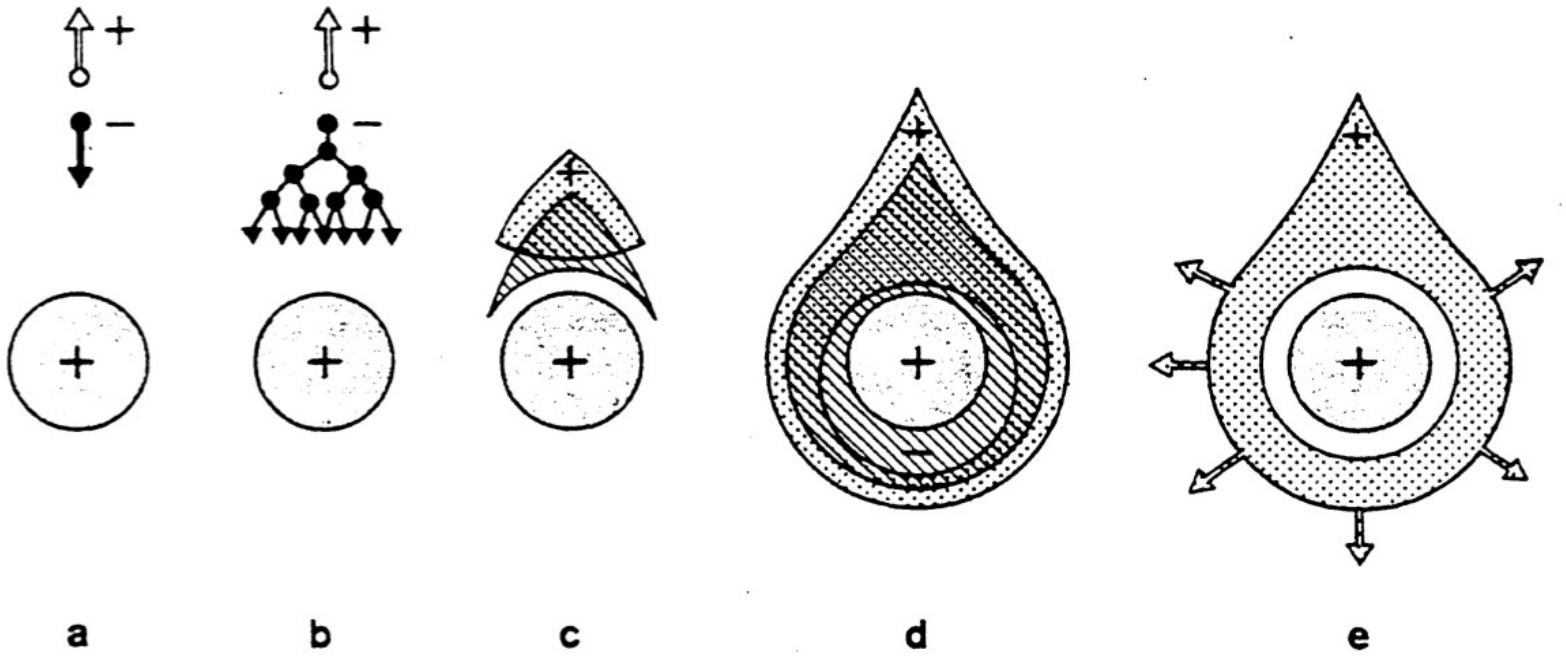



Image Source: Principles of Operation of Multiwire proportional and Drift Chambers – F.Sauli (CERN 77-09)

Single primary electron proceeds towards the anode, in regions of increasingly high fields, experiencing ionizing collisions; due to the lateral diffusion, a drop-like avalanche, surrounding the wire, develops. Electrons are collected in a very short time (1 ns or so) and a cloud of positive ions is left, slowly migrating towards the cathode.

# *Choice of Fill Gas*

Avalanche multiplication occurs in all gases but there are specific properties required from a "magic" gas mixture as:

Low working voltage (low ionization potential)
Stable operation at high gain
High rate capability (fast recovery)
Good proportionality

**Noble gases** are usually the principal components of a useful gas.**Argon** gives more primary ionization than Helium or Neon (Kr and Xe are better and have been used but they are expensive)

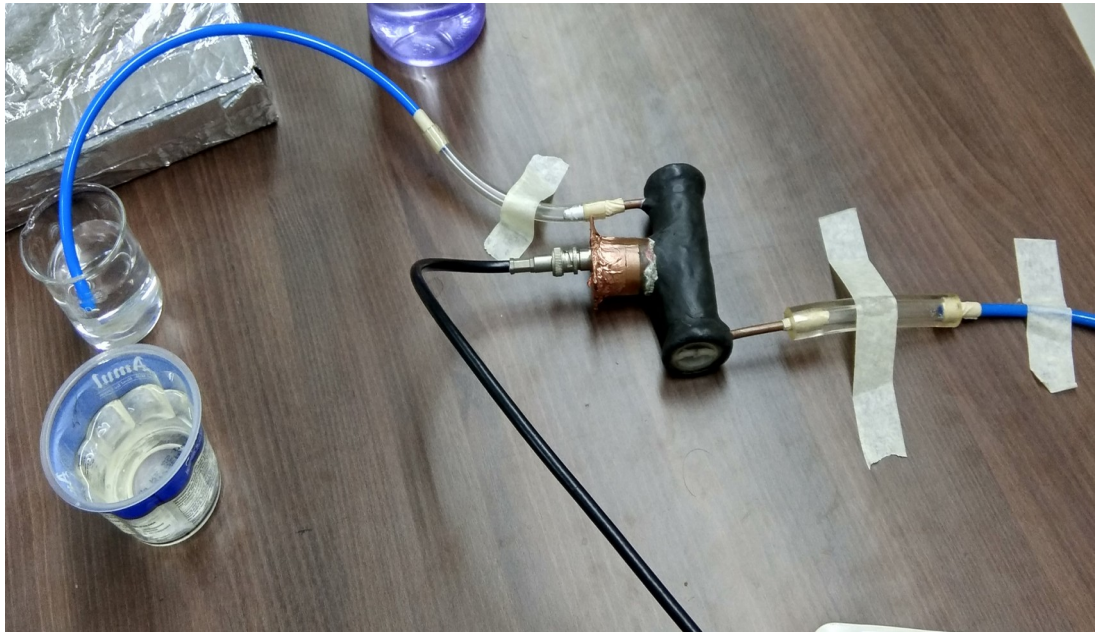
BUT a chamber full of argon does not produce stable operation and suffers breakdown :

High excitation energy for noble gases (11.6eV for Ar) means that UV photons emitted from atoms excited in the avalanche process have enough energy to eject photoelectrons from the cathode material. Photoelectrons initiate further avalanches.

Process becomes self-sustaining continuous discharge.

The situation can be improved by the addition of various polyatomic gases which have many non-radiative vibrational and rotational excited states covering a wide range of energies.
e.g. methane ($CH_4$), isobutane ($C_4H_{10}$), $CO_2$

# Experimental Setup



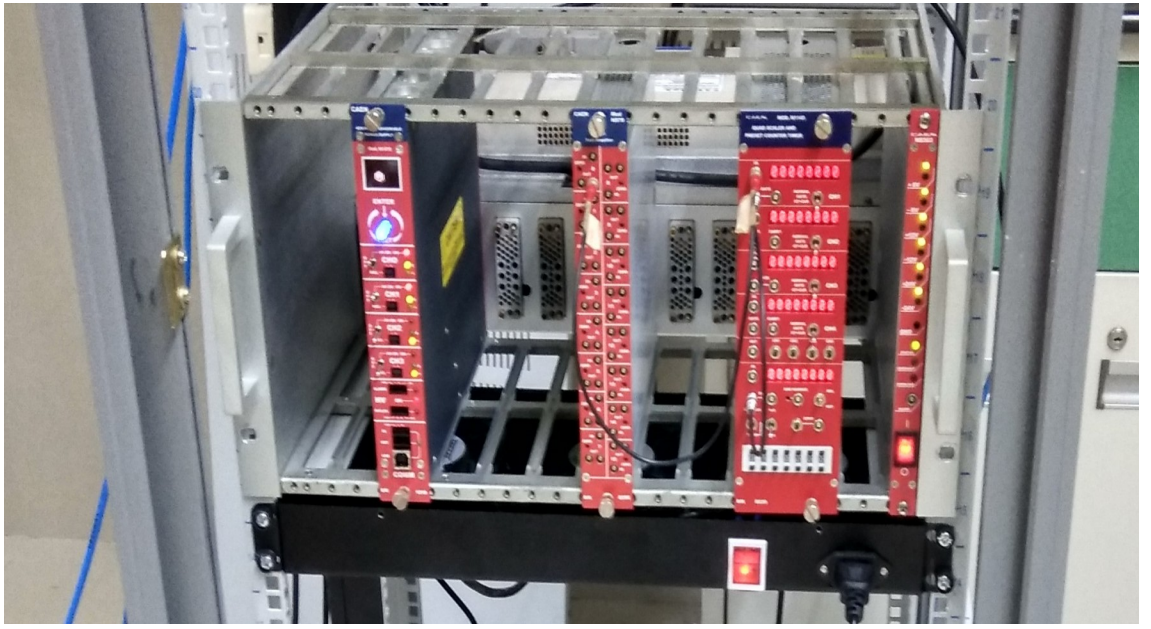
CATHODE : Cylindrical Copper plate

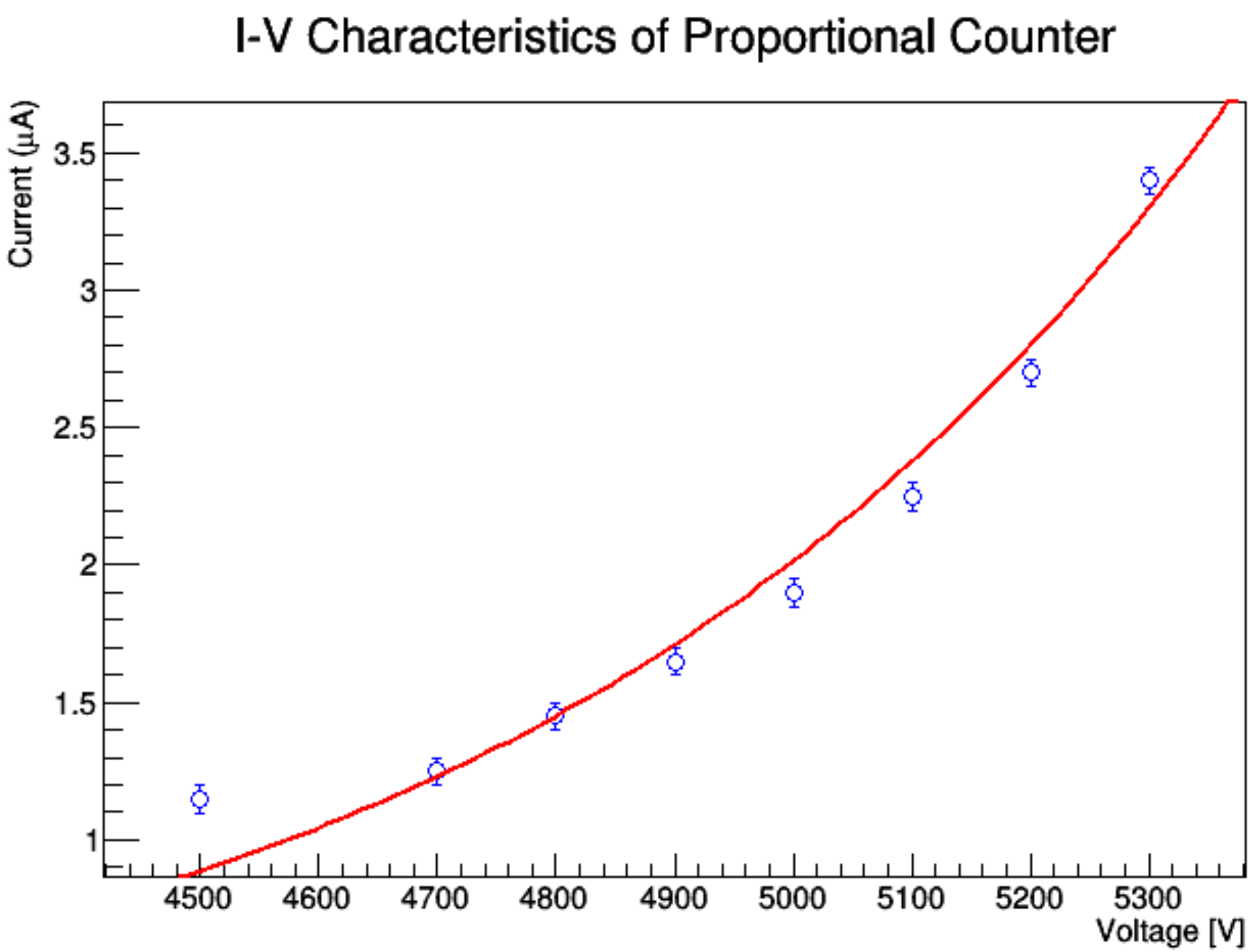
ANODE : Copper Wire

GAS MIXTURE : Ar:$CO_2$ (70:30)

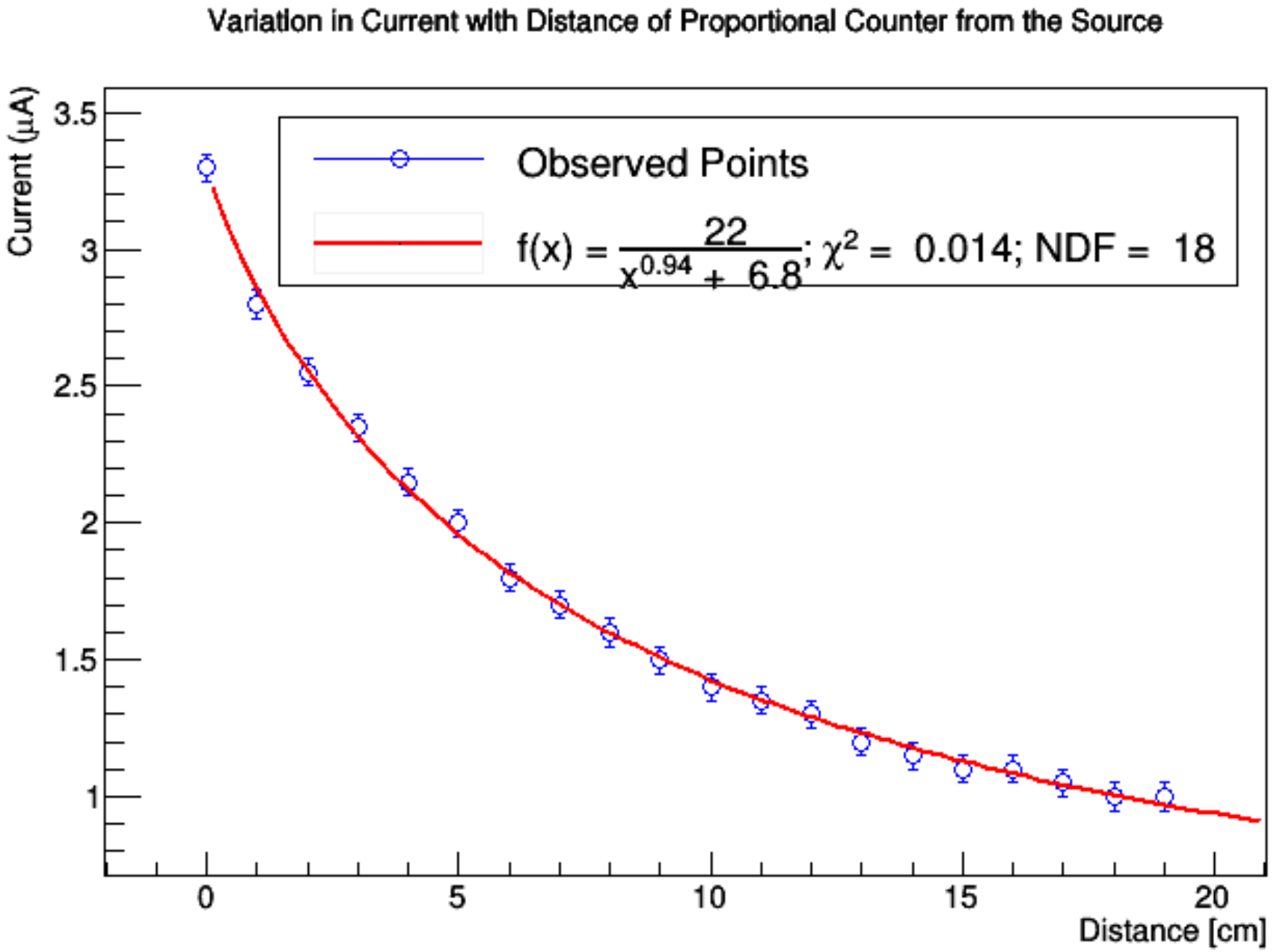
X-Ray Source : $^{55}Fe$

High Voltage Module






Current increases exponentially with Voltage.




Current decreases as we increase the distance of source from the proportional counter.

# *SUMMARY*

I-V characterstics of a Proportional counter has been studied along with the variation of current with distance of source from the counter.

References :


1. Principles of Operation of Multiwire proportional and Drift Chambers – F.Sauli (CERN 77-09)
2. Techniques for Nuclear and Particle Physics Experiments – William R.Leo


Thanks...