CLAS-Note 96-005

Calculation of Drift Chamber Gas Gain

Mac Mestayer
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Introduction

I have written a simple program (listing included) to calculate the gain of a chamber with an hexagonal wire arrangement. I have adjusted the key parameters of the program in order to agree with measurements of gas gain done by Mark Jones of William and Mary (memo included). Using these calibrated parameters, I have calculated the gas gain versus voltage for Regions 1, 2 and 3; using the given wire spacing and assuming a 50:50 Argon:Ethane mixture for Regions 1 and 3 and a 50:50 Helium:Ethane mixture for Region 2.

1 Description of the Calculation

The calculation consists of the following steps:

- Calculate **Ecrit**, the electric field strength at which the avalanche begins, where $Ecrit * \mu = i$ where **i** is the minimum ionization potential for the mixture, and μ is the mean free path.
- Calculate **Rcrit**, the radius at which the avalanche begins from $Ecrit = C/Rcrit$ and $C = V * fac/log(D/Rw)$ where V is the voltage, D is the maximum drift distance, Rw is the sense wire radius, and **fac** is a capacitance factor which is 1. for a tube geometry and 0.8131 for a hexagonal field wire arrangement.
- Calculate the gain as two to the power **ndouble**, the number of doubling lengths. **Ndouble** is equal to the distance ($= Rcrit - Rw$) divided by the mean free path.
- The only complication is that I use a **different** value for the mean free path used to calculate the beginning distance of the avalanche as opposed to the mean free path used to calculate the number of times the avalanche doubles. The latter is at higher values of electric field, so I call it **delhi** while the former is called **dello**.
- I calibrated the parameter values using Mark Jones' data (included) by the following:
  - Adjust **dello** to give the correct voltage at unity gain.
  - Then adjust **delhi** to give the correct gain at high voltage.

2 Comments on the Gain Measurement

The gas gain measurements were done by Mark Jones (see attached memo). He did the measurements for a 1 cm diameter straw tube with a $25\mu m$ sense wire for various mix ratios of argon and ethane and of helium and ethane. The important point is that he could normalize to the point of unity gain by noticing the point at which the ratio of outgoing current to input light intensity began to change with increasing voltage (i.e. avalanche beginning). As described above, I adjusted two of my gas parameters to reproduce his results. I then calculated the gains for our chamber geometry by changing one factor to account for the different capacitance of the hexagonal geometry compared to the straw-tube geometry.

3 Results

The results are displayed in figures 1, 2 and 3. Figures 1 and 2 are copies of Jones' experimental points with my calculations overplotted. Figure 3 shows the calculated curves for the actual Region 1, 2 and 3 geometries. For Region 2, two curves are shown: one for 50/50 Ar/Eth and one for 50/50 He/Eth.