Surface efficiency of a THGEM

CERN's Summer Student Project

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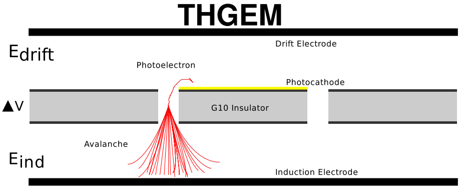
Outline

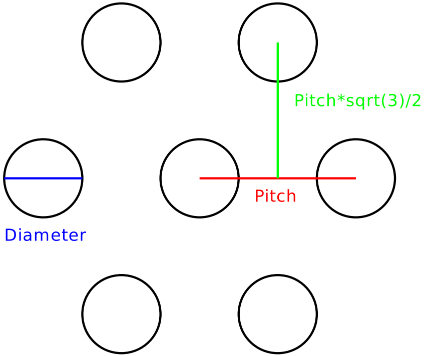
What is a THGEM?



- A composite grid consisting of two metal layers separated by a thin insulator, etched with a regular matrix of open channels.

Geometrical Parameters

Geometrical arrangement of the THGEM



The geometry is characterized by two elements: the pitch, here in red, and the diameter ,here in blue, of the holes.

Photoelectron Backscattering

- Since 1955 in a work by L.B Loebe it was recognized that once escaped from a photocathode some electrons diffuse back, even in the presence of electric field, due to the elastic collisions with the gas molecules
- As is stated in Di Mauro et al 1996 one of the most important parameters contributing to photoelectron backscattering occurrence is **the ratio of elastic collisions versus inelastic collisions**.

Problems

- The electron may be produced in a point where the electrical field does not take it to towards the holes.
- The electron may suffer from photon backscattering

Definitions

- We call the area where those non detected electrons area created Unusable area.
- We define Effective area as the total area of the surface minus the surface of the holes and the unusable area.

Main problem

Main problem

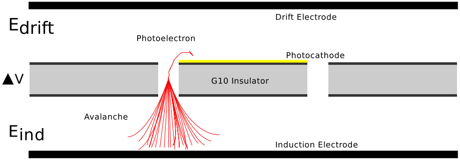
Maximize the percentage of Effective area or equivalently minimize the percentage Unusable area.

General Simulation Route

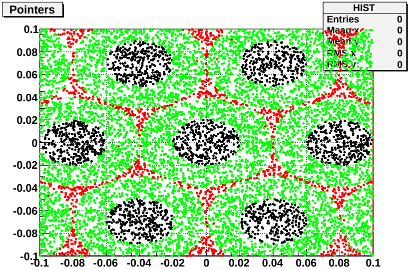
- Geometry and Finite Element Method with the software **Ansys**
- Gas simulated with **Magboltz**
- **Garfield** calculated the trajectory with **Runge-Kutta-Fehlberg**

Simulation I: Binary Decision

- We paint green a point if the electron produced there makes it to the the induction electrode. Otherwise we paint it red.



Output Example of Simulation I



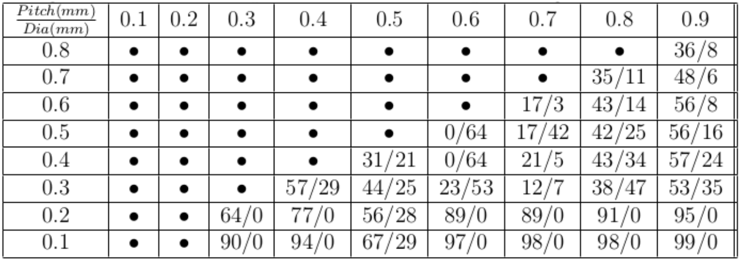
Result of a particular simulation of electrons generated randomly all over the surface. The geometry of this simulations is given by diameter=0.04 cm and pitch=0.08 cm. The electrostatic values are $\Delta V = 600\frac{V}{mm}$, $E_{drift} = 0$, $E_{ind} = 300\frac{V}{mm}$.

Being More Systematic

- We can approximate the unusable area by calculating the proportion of all the produced electrons that do not make it to the collector space.
- We can approximate the effective area by calculating the proportion of the electrons that made it.

Systematic results

- Then we can be systematic and produce tables like this:



$\frac{Pitch(mm)}{Dia(mm)}$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.8	•	•	•	•	•	•	•	•	36/8
0.7	•	•	•	•	•	•	•	35/11	48/6
0.6	•	•	•	•	•	•	17/3	43/14	56/8
0.5	•	•	•	•	•	0/64	17/42	42/25	56/16
0.4	•	•	•	•	31/21	0/64	21/5	43/34	57/24
0.3	•	•	•	57/29	44/25	23/53	12/7	38/47	53/35
0.2	•	•	64/0	77/0	56/28	89/0	89/0	91/0	95/0
0.1	•	•	90/0	94/0	67/29	97/0	98/0	98/0	99/0

- The first number here is the unusable area and the second one the effective area.

Extraction Efficiency

- From an article by Azevedo et al 2010 we got the values of the extraction efficiency and add them to our model.

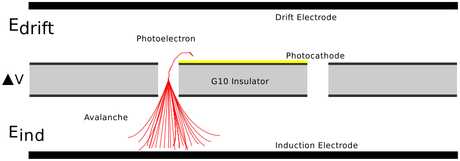
```
double extrprob;
      double flag=gRandom ->Uniform(0,1);
      if( 190  <= -ez < 570 ){
extrprob=.70;
      }
      else if( 570 <= -ez < 950 ){
extrprob=.75;
      }
      else if( 950 <=  -ez < 1330 ){
  extrprob=.80;
      }
      else if( 1330 <= -ez < 1710 ){
extrprob=.85;
      }
      else if( 170 <= -ez ){
extrprob=.85;
      }
      if(flag>extrprob){
printf("Exctraction field not enough \n");
continue; // Don't calculate avalanche
      }
```

Simulation II

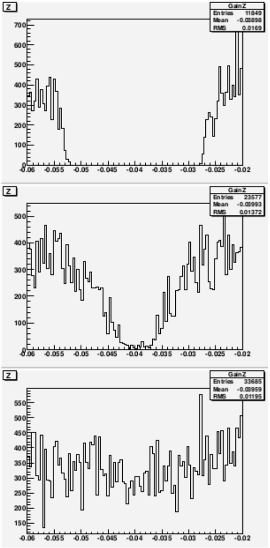
- We define **effective gain** as the number of avalanche electrons produced by an electron staring at that particular point that make their way to the induction electrode o close enough.

Simulation II

- In our simulations we calculate the effective gain as a function of position in a line that connects two hole's centres varying the value of drift fields E_{drift}.

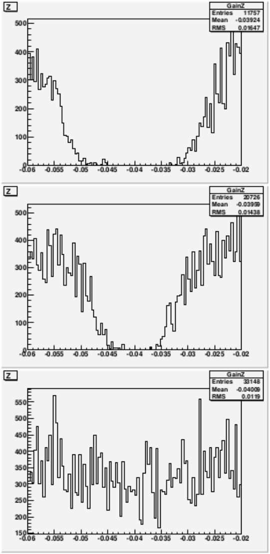


Output of Simulation II



From top to down we have the simulation with the drift field values: $170\frac{V}{mm}$, $83\frac{V}{mm}$, $17\frac{V}{mm}$ In the x axis we graph position from the edge of one hole to the other at the right of it, on the y axis we have the gain. We can see that the gain increases at the center with E_{drift} approaching to zero.

Output of Simulation II



From top to down we have the simulation with the drift field values: $-17\frac{V}{mm}$,$-83\frac{V}{mm}$ and $-170\frac{V}{mm}$. In the *x* axis we graph position from the edge of one hole to the other at the right of it, on the *y* axis we have the gain. We can see that the gain increases at the center with E_{drift} approaching to zero.

Further Work

- Have more precise table of the simulation I.
- Have gain maps with respect to other parameters
- Full two dimensional map

Acknowledgements

- To my University, Mexican Physics Society and CERN for their financial assistance.
- To Rob Veenhof and Guy Paic for their patience and willingness to teach and help me through this project.