GTS - Garfield-based Triple-GEM Simulator

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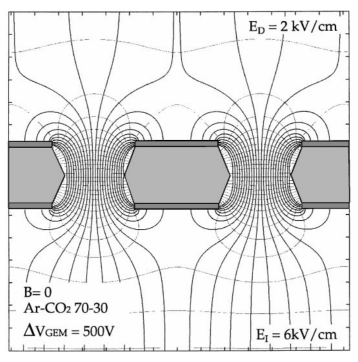
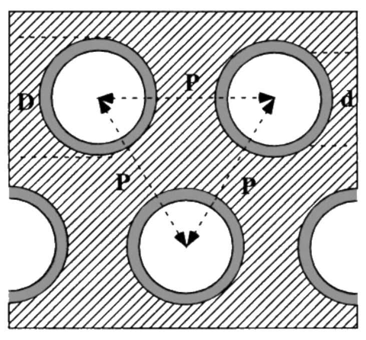
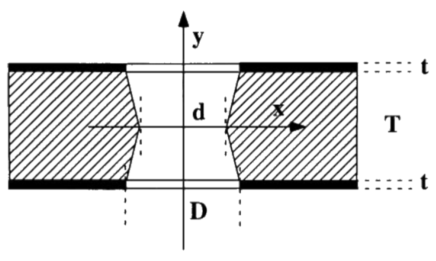
Gas Electron Multiplier







Invented by F. Sauli in 1997

A 50 µm **Kapton** foil with 5 µm **copper** on the faces.

High density **holes** with 50 (70) µm diameter and 140 µm pitch.

A voltage difference of hundreds of Volts between the two faces creates **electric field** of 10^5 kV/cm.

Electron crossing the hole generates an **avalanche**.

Stacks of several GEM foils can reach a **gain of 10^4**

Needs and aim

Well known software in literature, such as Garfield ++ are able to performe a microscopic simulation of the gaseous detector with a large CPU time consumption, around 1 day per event.

The idea of this work is to parametrize the key parameter in the simulation and to reduce time needed for a simulation up to 1 second per event.

GTS has been validated with a fix particle type and energy but its are application can be extended in a wider range of energies and particle type.

Simulation

- The simulation generates the signal response to the passage of a ionizing particle

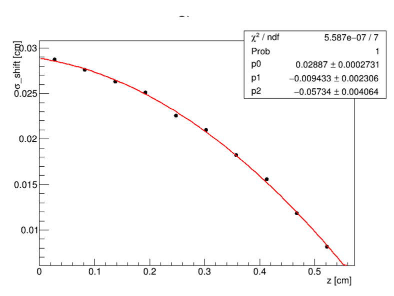
Variables are extracted from **Garfield** and they are parametrized to be implemented **separately** in the simulation.

The results of this simulation and Garfield are in agreement but the **time consumption** is well reduced.

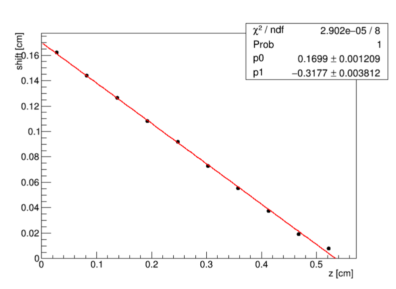
The simulation is divided in three **indipendent topics**:

1) Ionization
2) Gain measurement for a single GEM
3) Effect of diffusion on space and time measurements by drifting electron separately in the various gaps

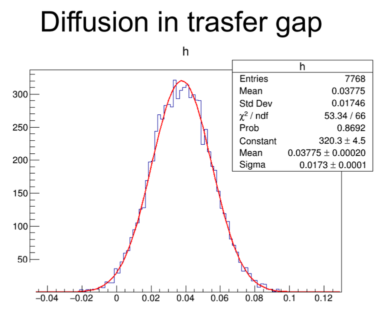
Spatial diffusion in drift gap



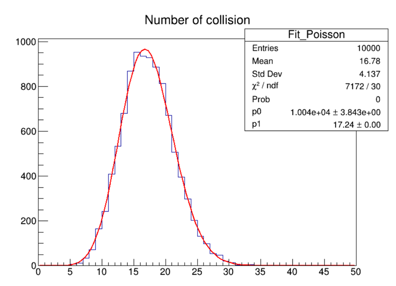
Spatial shift in drift gap



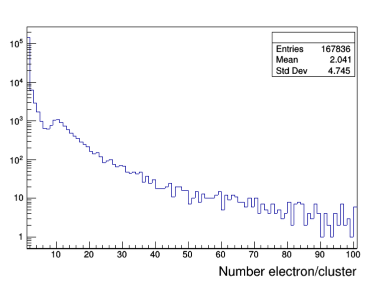
Diffusion in trasfer gap

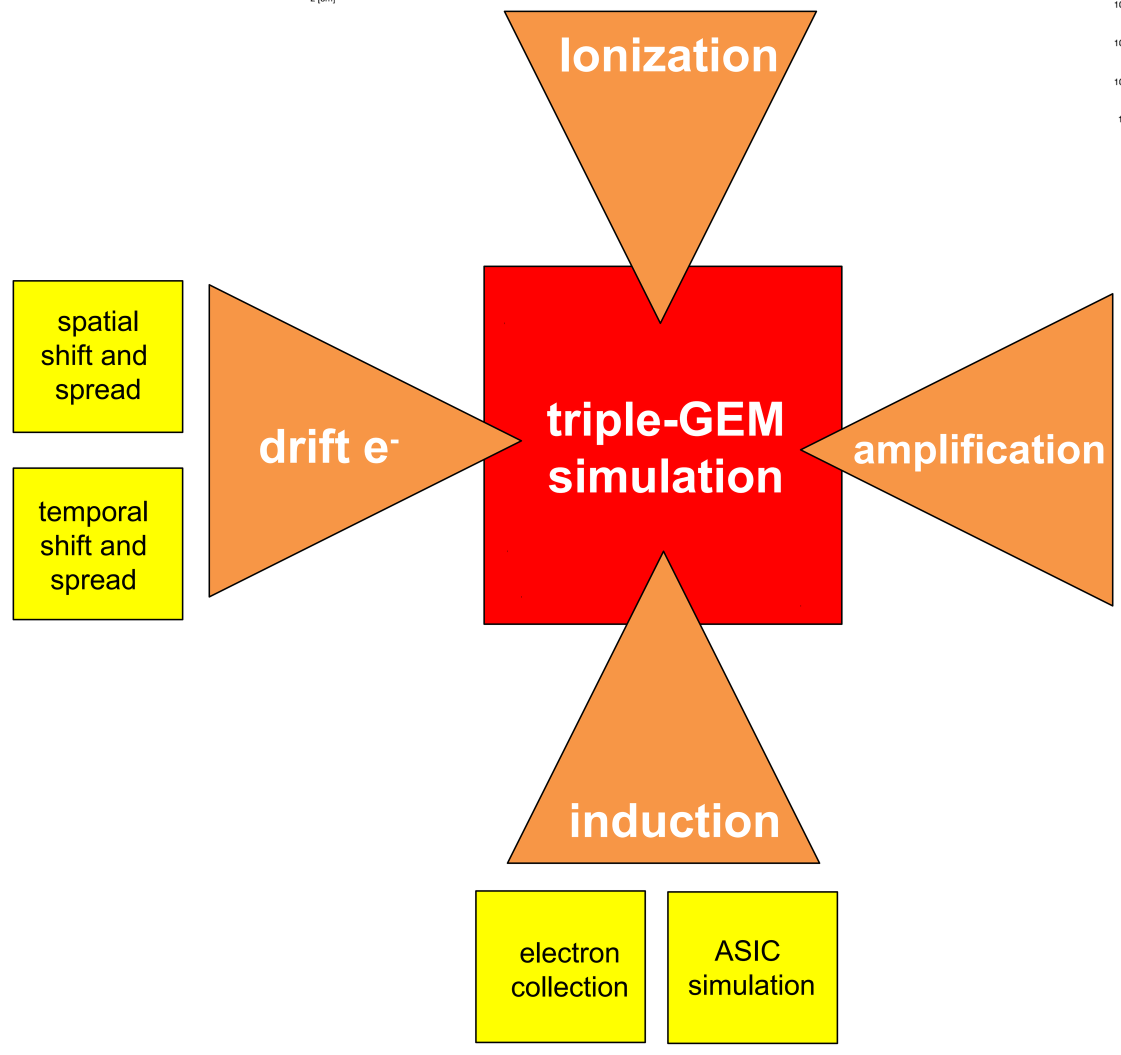


Number of collisions

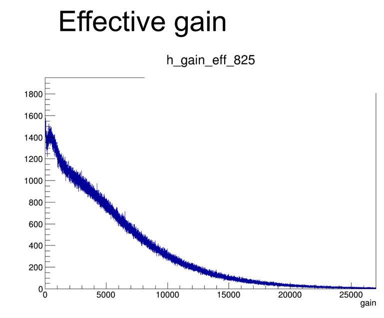


Number of electrons/collision



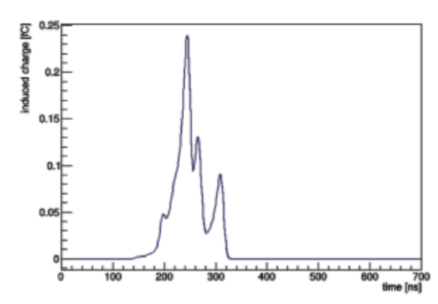


Effective gain

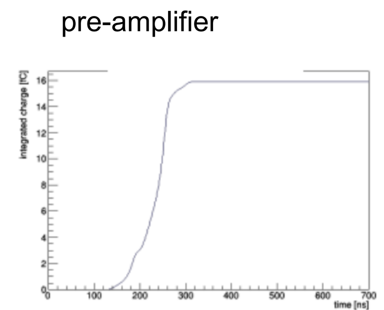


The electron arriving on the strip are used to build up the induced current. The consistency of this technique has been compared to a method using the Shockley-Ramo theorem. A pre-amplifier integrates the charge and a shaper with a characterist time of 50ns define the final signal measured by the electronics

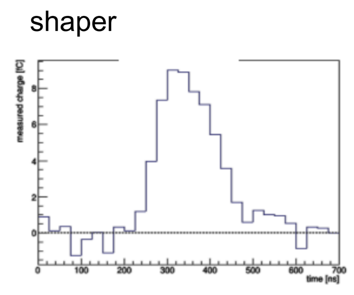
Induced current



pre-amplifier



shaper



Here the steps of this work:

1) Generate the **electron cluster** with an exponential probability along the path

2) Generate the **electrons** in the cluster

3) Simulate the **GEM gain** and trasparency

4) **Drift the electrons** to the induction gap

5) **Induce** the current on the strips

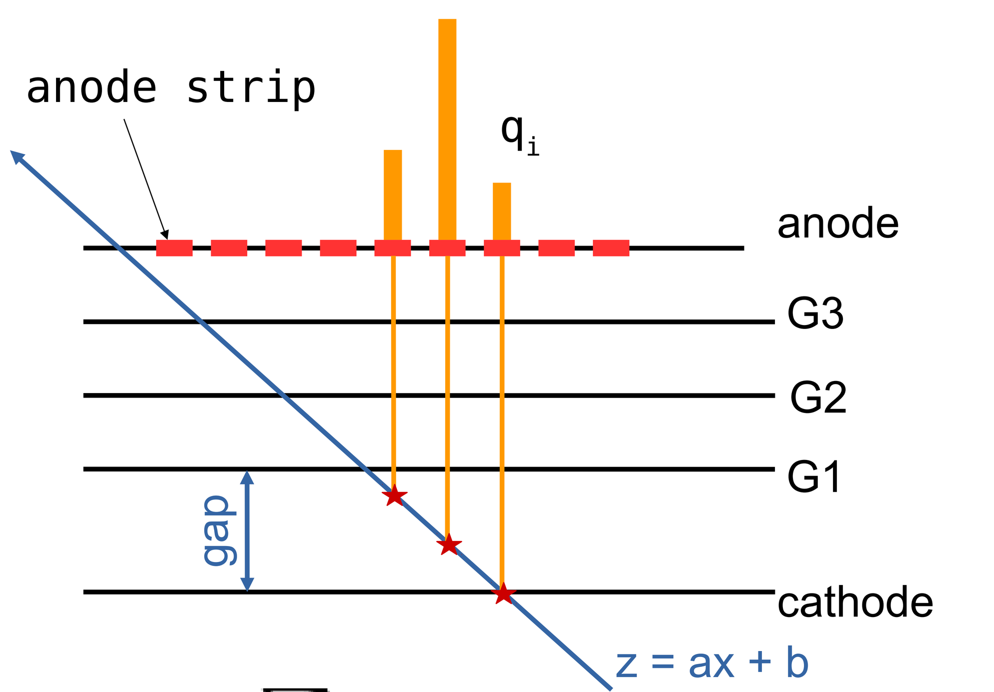
6) Simulate the ASIC response

7)Reconstruct the particle position with charge and time info

8)Run 70k simulation with different incident angle of the particles

9)Change the tuning parameters to improve the matching with the experimental data and re-run

Reconstruction



$$x_{cc} = \frac{\sum x_i q_i}{Q_{tot}}$$

$$x_{\mu TPC} = \frac{gap/2 - b}{a}$$

Each strip measures charge and time. The charge information is used for the **Charge Centroid**. **µTPC** associates a bidimensional point to each fired strips and reconstructs the particle path in the drift gap.

The tuning

The simulated **cluster charge and multiplicity** are compared, as well as the **spatial resolution**, to the data collected in a **test beam** with **planar** triple-GEM detector. Tuning factors have been evaluated to improve the matching with the experimental data. A Chi-square minimization has been performed with a scan of the *gain tuning factor* and *diffusion tuning factor*.