"Monitoring chamber simulation and analysis"

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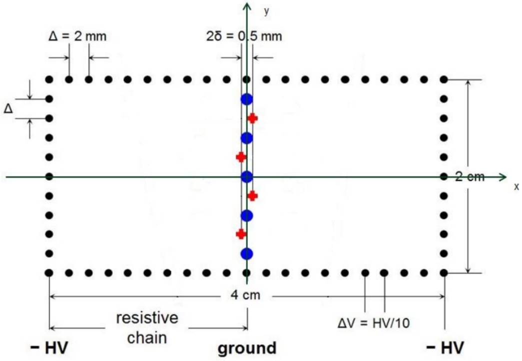
- Simulation on the Monitoring chamber
- Analysis on the simulation's results

Framework structure

- Libraries:
  - `Garfield`
  - `ROOT`
- Simulation and analysis framework:
  - `GAS-SIM`: Simulation different gas-mixtures
  - `SIM`: Simulation of electric field configuration and tracks through the chamber
  - Theoretical calculation of the drift velocity: `calcMeanVdrift`
  - Analysis macros

Simulation on the Monitoring chamber

- The macro for the simulation is: `sim.C`
  - For symmetries we are performing the simulation on one quarter of 2D-scheme of the chamber
  - Dimensions: $-2cm < x < 0cm$, $0 < y < 1cm$



1) Implementation of the chamber's structure:

- Medium (mixture of gas)
- Geometry: the box in itself
- Wires

2) Eectric field configuration:

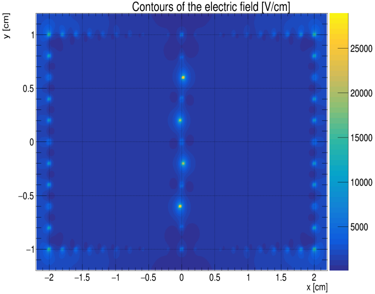
1. We vary the V on the guard-wires ($[-800, 0]V; 25V$)
2. We vary the V on the sense-wires ($[0, 1200]V; 25V$)
3. The voltage on the field-wires is fixed on $-2000V$
4. We fix $Oz = 0$ and scan the electric field per each Oxy-plane along the Oy-axis from ($[0, 0.9]cm; 0.1cm$)

3) Generation of the tracks:

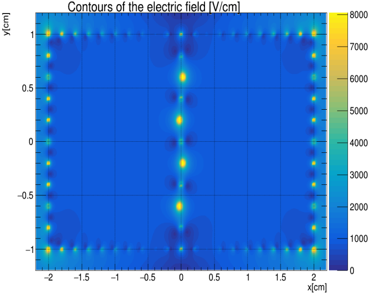
1. Avalanche parameters possible to set up like: time and spatial interval, etc ...
2. Tracks: start from $y = 1$ and $x = \pm 1$ and in the negative Oy-direction with an angle θ extracted from an uniform distribution $\theta \pm 12^\circ$

Electric field configuration

Electric field configuration with $V_g = 0V$, $V_s = 0V$

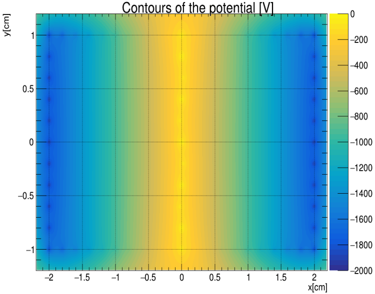


Electric field configuration with $V_g = -350V$, $V_s = 925V$

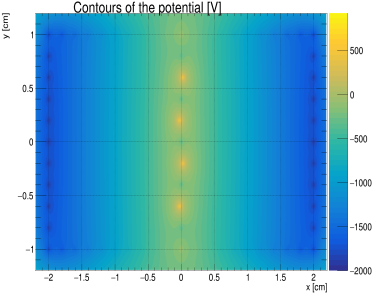


Potential configuration

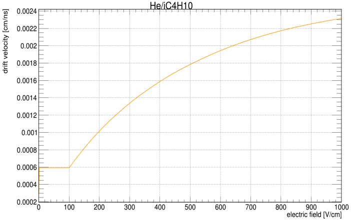
Potential configuration
with $V_g = 0V$, $V_s = 0V$

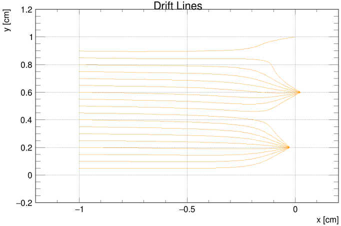


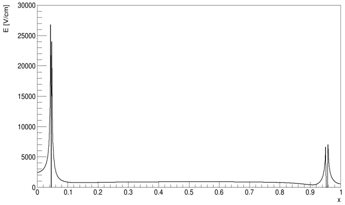
Potential configuration
with $V_g = -350V$, $V_s = 925V$



Chamber Physics parameters







.... Part II: ....
"Analysis Work"

Analysis on the simulation's results

⇒ Macros used for the analysis on the simulation's results are:

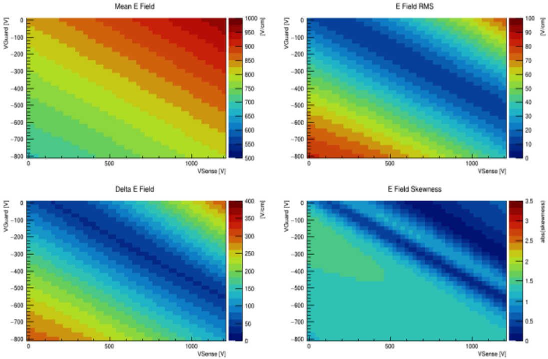
- `analisiSum.C`
- `AnalData1.C`
- `calcMeanVdrift.C`
- `plotVdTrend.C`

analisiSum.C: Part 1

• The main goal is to determine the optimized value for V_s and V_g to ensure a high and uniform electric field in the two drift cells.

• From the sim.C we obtain the RMS, skweness, electric field variation ΔE and the electric field configuration per each Oxy-plan along the Oy-axis and for different value of V_s and V_g.

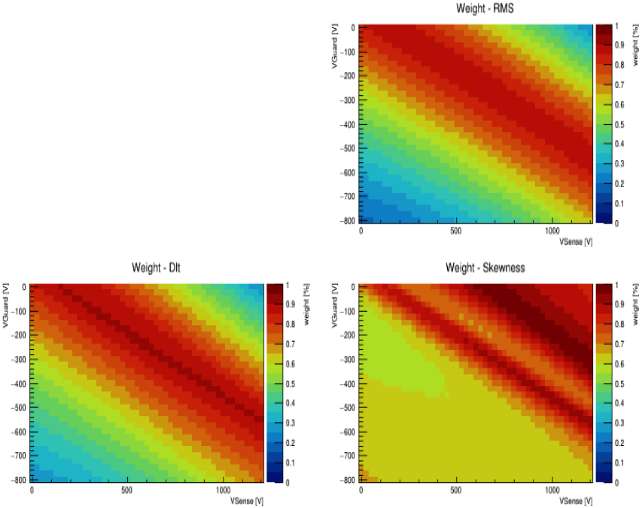
⇒ An example of the scan of the electric field, ΔE, RMS, skewness average values on the plane corresponding to the first sense wire in analysis.



• We calculate the weights for the RMS, skewness and the variation of the electric field ΔE:

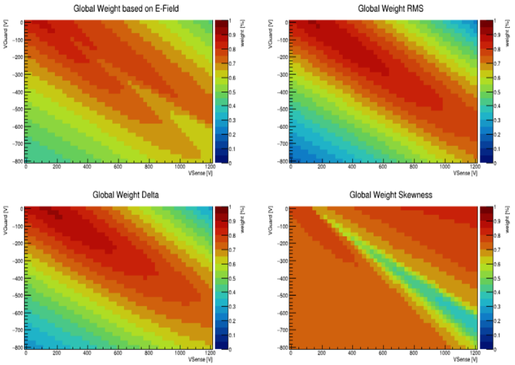
- We assign a weight value between 0-1 to each bin of the histograms normalizing the *Oz*-axis.
- We divide the value of each bin by a reference value.
- The reference value is choosen as a mean value to relative distributions with a confindence value of 3σ.
- If the weight value is > 1, then the given weight value will be just 1.
- The goal is to append a bigger weight to the minimal variation of the field, RMS and skweness, by doing a complementary histogram, where each bin is weighted as $1 - weight_{previous}$.

⇒ An example of the scan of ΔE, RMS and skewness for the first sense wire.



`analisiSum.C`: Part 2

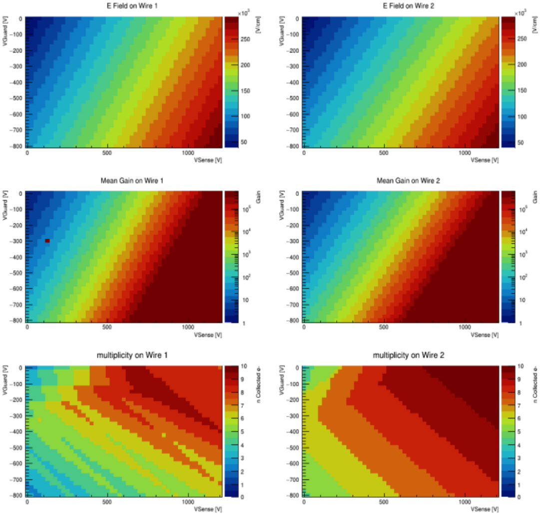
- We analyze the information of each scan along the Oy-axis, creating 3 histograms related to the RMS, skewness ad ΔE, where each bin is filled with the mean values of all the scans.
- Moreover, we create a global histogram, where each bin contains the avarage value of the weights from the previous histograms.



- top left: the global histogram that contains the average of the other three histograms.
- top right: average of ΔE for all the plane scans.
- bottom left: average of RMS for all the plane scans.
- bottom right: average of Skewness for all the plane scans.

analisiSum.C: Part 3

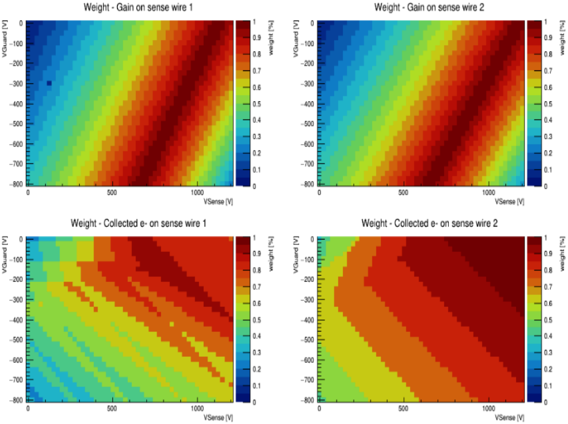
For the two sense wires in analysis, we study the electric field configuration, the number of collected electron and the gain value.



• We assign a weight also to the histograms for the gain and number of the collected electrons in the sense wires.
• The weights are assigned in the same way as in the previous explanation.
• In this case we divide the value of each bin by the number of simulated tracks.
• In case of the gain:

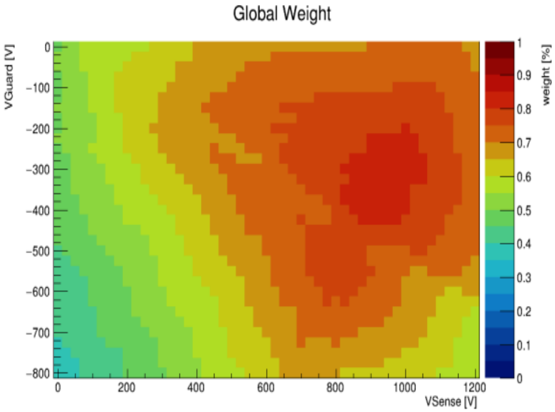
- The weights per each bin of the gain histogram has been assigned in logaritmic scale, where each bin has divided by a value of 10^5 (reference value for proportional counting region).
- If the weights are between 1-2, the new weights are obtained as $2 - weight_{previous}$.
- If the weights are > 2, we assign the value 0 for those weights.

⇒ The wheighted histograms for gain and number of collected electron of the two sense wires in analysis.



analisiSum.C: Part 4

- At last, we build a global histogram, where each bin contains the avarage value of the weights from the histograms of:
  - Electric field uniformity
  - Gain
  - Collected electrons of each sense wire
- From this global histogram, we can than obtain the optimized voltage values for sense and guard wires:
  - $V_s = 925V$
  - $V_g = -350V$

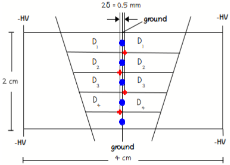


AnalData1.C

- The main goal is to determine the drift velocity values as a function of He content or pressure/temperature variations from the double peak Gaussian distribution.

Some remarks:

$$\begin{cases} t_2 = \dfrac{t_1 + t_3}{2} \mp \dfrac{2\delta}{v_d} \\ t_3 = \dfrac{t_2 + t_4}{2} \pm \dfrac{2\delta}{v_d} \end{cases} \rightarrow t_3 - t_2 \rightarrow \Theta = (t_1 + t_3 - 2t_2) - (t_2 + t_4 - 2t_3)$$



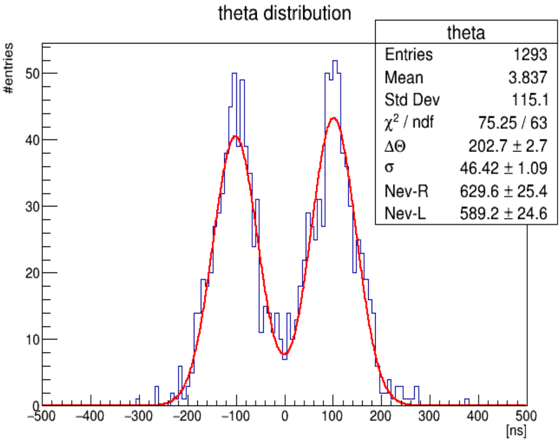
$$\Theta = \begin{cases} Left : \Theta_+ = +\dfrac{8\delta}{v_d} \\ Right : \Theta_- = -\dfrac{8\delta}{v_d} \end{cases}$$

- Θ will have double gaussian distribution.
- The distance between the two peaks is related to drift velocity:

$$v_d = \frac{16\delta}{\Delta\Theta}, \sigma_{v_d} = \sqrt{\left(\frac{16}{\Delta\Theta}\right)^2 \sigma_\delta^2 + \left(\frac{-16\delta}{(\Delta\Theta)^2}\right)^2 \sigma_{\Delta\Theta}^2} \quad (1)$$

- Identification of the drift time t_d on each single wire:
  - Weighted avarage of the drift time of those electrons with a minimal collected charge equal to 10^5 electrons.
  - Otherwise the information on the wire will be skipped.
  - The weights are evaluated by the ratio of the charge value recorded on the wire over the reference value of $5x10^5$.

Here an example of the double peak gaussian distribution for a mixture 89% He - 11% iC_4H_{10}, at $P = 760 torr$ and at $T = 300K$.



The drift value extrapolated from this distribution is:
$v_d = 1.97 \pm 0.03$ cm/μs

•The main goal is to make a comparison between the drift velocity value from the double peak gaussian distribution and its theoretical value.
• It simulates theoretically the drift velocities v_d for different gas mixtures according to two methods:

- $v_{d,1} = f(\mid \vec{E} \mid)$
- $v_{d,2} = \frac{D_d}{t_d}$

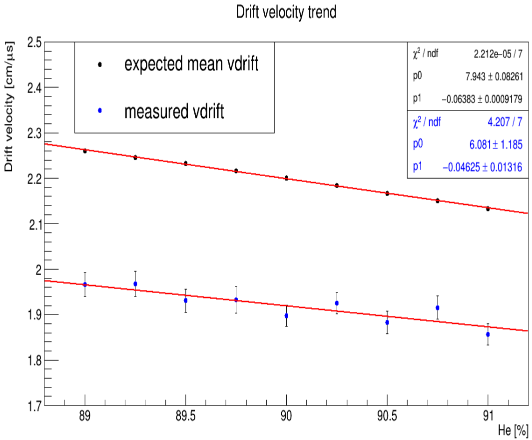
Both of the v_d-values are token as a mean value:

$$\bar{v}_{d,1} = \frac{\int v_d \delta E}{\Delta E}$$

$$\bar{v}_{d,2} = \frac{v_{d,2}}{N_{DriftLines}}$$

plotVdTrend.C

- It does the plots of the theoretical and experimental drift velocity:



Conclusion

There is still a shift between theoretical value and experimental value of drift velocity.