1 Electric field in the cell

GARFIELD program [1] has been used to calculate field in the cell, to simulate drift velocity in pure DME and to estimate drift time for our chamber geometry.

Electric field was calculated with high voltage on the cathode set to U=-1850V and magnetic field 2.2 T. Figure 1 presents drift field lines and constant drift time contours (step 10 ns) for DME at standard conditions (T=293^o, P=760 Torr). 3D graph of the electric field strength E is shown on fig.2. Details of the field strength are presented on the fig.3 and fig.4. Contours of the field E are plotted on the fig.3. Step of contours equal to 760V/cm, or 1 V$\cdot$cm$^{-1} \cdot$ Torr^{-1} in terms of reduced field. Closest to wire contour corresponds to E=15200 V/cm or 20 V$\cdot$cm$^{-1} \cdot$ Torr^{-1} and located about 0.2mm from the wire center. Figure 4 shows the field strength E along cathode surface (x=0 through x=4mm) and along the border of two adjacent cells (from (x=2mm,y=-2mm) to (x=2mm,y=2mm)).

2 Drift velocity and drift time

Calculated drift velocity vs E/p is presented on fig.5 for two different ranges of reduced field E/p. Drift velocity at E/p range from 0 up to 15-20 V$\cdot$cm$^{-1} \cdot$ Torr^{-1} is close to existing measured data. GARFIELD does not provide accuracy at high field and no directly measured drift velocity data. Fortunately it would have insignificant influence because of the region with high field has small size in our chamber and electrons cross this area for few nanoseconds (see fig.1 and fig.3).

Drift time has been estimated using XT-plot command in GARFIELD drift section. XT-plot calculates shortest drift time from track to the wire using drift lines which are set in program. Number of lines was set to 20000 for calculation of drift time. XT-plot does not take into account cluster structure and so data will differ from real track especially for minimum ionising particles. Also XT-plot accuracy is not better than 0.1%.

3 Influence of the temperature and pressure on the drift velocity

Variation of drift velocity with temperature for E/p range 0 through 20 V$\cdot$cm$^{-1} \cdot$ Torr^{-1} is shown on fig.6. Absolute variation of drift velocity for ΔT=1^o and ΔT=5^o is plotted on the top graph. Relative variation of the drift velocity for ΔT=1^o is presented on the bottom graph. At low field strength E (or E/p) relative variation ΔV/V= ΔT/T is in agreement with Ref. [2].

Drift velocity varies as function of reduced field E/p. For saturated gases change of pressure will have negligible effect. DME is nonsaturated gas and change of pressure will effect drift velocity.

Change of temperature and/or pressure causes change of drift velocity and drift time. It could results in mistake of track distance calculation if that change is not taken into account. Drift time plots for various track angles for different values of temperature and pressure were used to estimate that mistake. Example of drift time for few track angles vs both of X-distance from the wire and DOCA at standard conditions is shown on fig.7. Similar graphs were used to estimate shift of DOCA due to change temperature or pressure.

Follow procedure was used to estimate mistake. For example, we have two drift time plots at T=293^o and T=294^o. For given X-distance or DOCA$_{293}$ at T=293^o we have a drift time T$_{293}$. Now we have to calculate what will be X-distance or DOCA$_{294}$ for track on the second plot when drift time T$_{294}$=T$_{293}$. Difference DOCA$_{293}$-DOCA$_{294}$ is mistake which we can get if we do not take into account change of the temperature.

The similar procedure was used to estimate shift of DOCA of track to wire for different value pressure.

Figure 9 shows shift of DOCAs for $\Delta T=1^o$ vs DOCA for 8 values of track angles. Figure 10 presents similar graphs for $\Delta P=10$ Torr for the same angles. Data on fig.10 were smoothed during plotting.

Behaviour of these plots can be explained by figure 8. This figure shows coordinates of the "first cluster" and lines, perpendicular to tracks for different track angles. One can see that perpendicular lines coincide with the coordinates of the "first cluster" origin near wire only. For any angle excluding 0^o after some distance of track from the wire the first cluster reached wire comes from the cathode surface. These points correspond to maximum value of ΔDOCA on figures 9 and 10.

As can be seen from figure 9 that change of temperature $\Delta T=1^o$ (0.34%) causes shift of DOCA up to 4 μm. Similar change of pressure $\Delta P=10$Torr (1.31%) gives shift of DOCA up to 17-18 μm. We can maintain temperature but are forced to follow atmosphere pressure which could change much more than 10 Torr.

In Ref. [3] another option is foreseen. Authors plan maintain absolute pressure and can compensate change of temperature by changing of absolute pressure in the chamber.

References

[1] Garfield, a drift-chamber simulation program. Version 5.35

[2] G.Schultz and J.Gresser, NIM 151(1978) 413-431.

[3] S.E.Baru et al. NIM A409(1998) 23-25.