A Study of Drift Times in PrM

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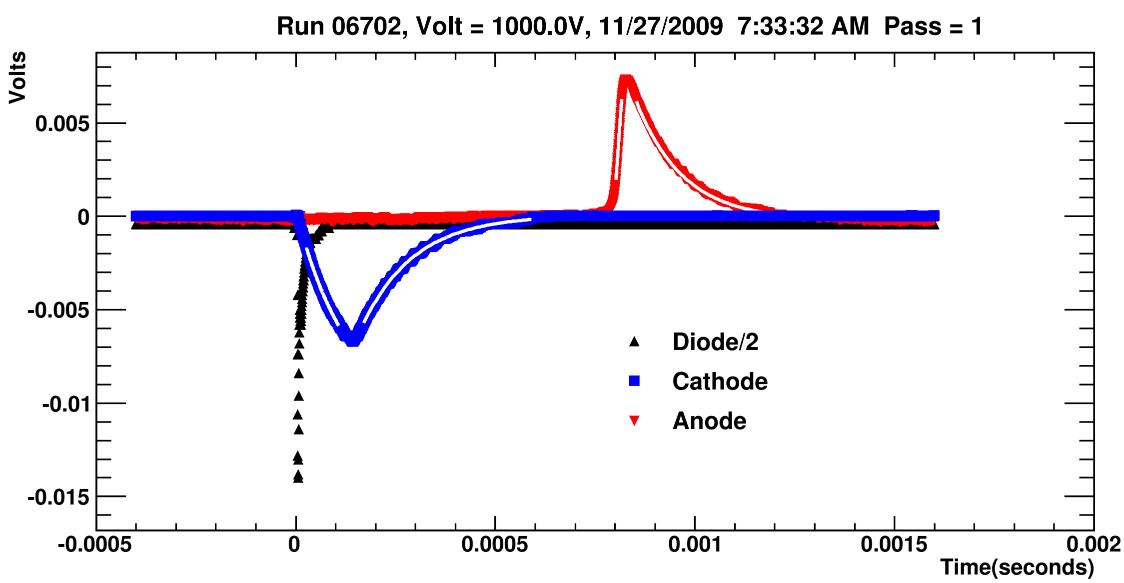

Figure 1: An example of PrM readout.

Fig.1 shows an example of the PrM diode, cathode and anode pulse shapes. We tried to understand the electron drift times from cathode to cathode grid and from anode grid and anode.

1 Drift time from cathode to cathode grid

The distance between cathode and cathode grid is

$$L_{C-CG} = 0.700'' = 1.778cm. \tag{1}$$

The voltage between cathode and cathode grid is

$$V_{C-CG} = 50V. \tag{2}$$

Therefore the field strength is

$$E_{C-CG} = 28.12V/cm. \tag{3}$$

According to [1], the corresponding electron drift velocity is

$$v_{d_{C-CG}} = 0.15mm/\mu s. \tag{4}$$

Thus the electron drift time from cathode to cathode grid is

$$t_{C-CG} = L_{C-CG}/v_{d_{C-CG}} = 119\mu s. \tag{5}$$

The left plot on Fig.2 shows the distribution of cathode drift time for 50 PrM runs calculated by Stephen's code. It indicates the measured drift time is

$$T_{C-CG} = (136 \pm 4)\mu s \tag{6}$$

The measured drift time is 14% higher than the calculated value. But given the large uncertainties, this may be reasonable.

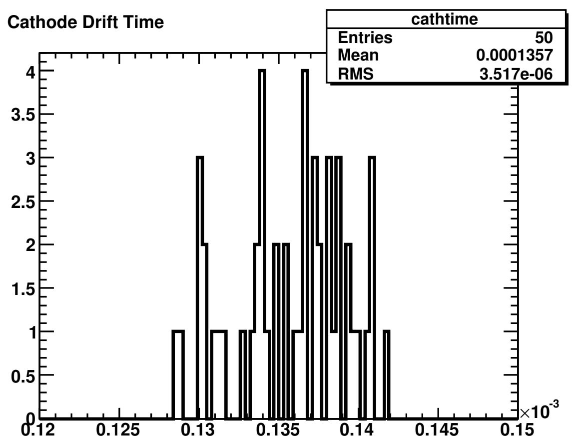

Figure 2: Distributions of cathode drift time and anode drift time.

2 Drift time from anode grid to anode

We also calculated the drift time from anode grid to anode in the same manner.

$$\begin{aligned} L_{A-AG} &= 0.310'' = 0.7874cm & (7) \\ V_{A-AG} &= 1000 \times \frac{125}{125 + 16 \times 50} V = 135.1V & (8) \\ E_{A-AG} &= 171.6V/cm & (9) \\ v_{d_{A-AG}} &= 0.80mm/\mu s & (10) \\ t_{A-AG} &= 9.8\mu s. & (11) \end{aligned}$$

The measured anode drift time is (Fig.2)

$$T_{A-AG} = (26.6 \pm 0.3)\mu s. \tag{12}$$

The measured drift time is almost 3 times as big as the calculated value.

3 New purity monitor module

The default purity monitor module design does not allow a direct measurement of the voltage between the anode and the anode grid. Walter modified the module design so that we can measure the anode-anode grid voltage directly. We took some data using the newly modified module. Here are the voltage measurements:

$$V_A = 978V \quad (13)$$
$$V_{AG} = 846V \quad (14)$$
$$V_{A-AG} = (978 - 846)V = 132V \quad (15)$$

The measured voltage is very close to the calculated one for the default design. We can calculate the field strength and drift time between anode grid and anode:

$$E_{A-AG} = 167.6V/cm \quad (16)$$
$$v_{d_{A-AG}} = 0.80mm/\mu s \quad (17)$$
$$t_{A-AG} = 9.8\mu s. \quad (18)$$

The measured anode drift time is (Fig.3 right plot)

$$T_{A-AG} = (25.0 \pm 0.2)\mu s. \quad (19)$$

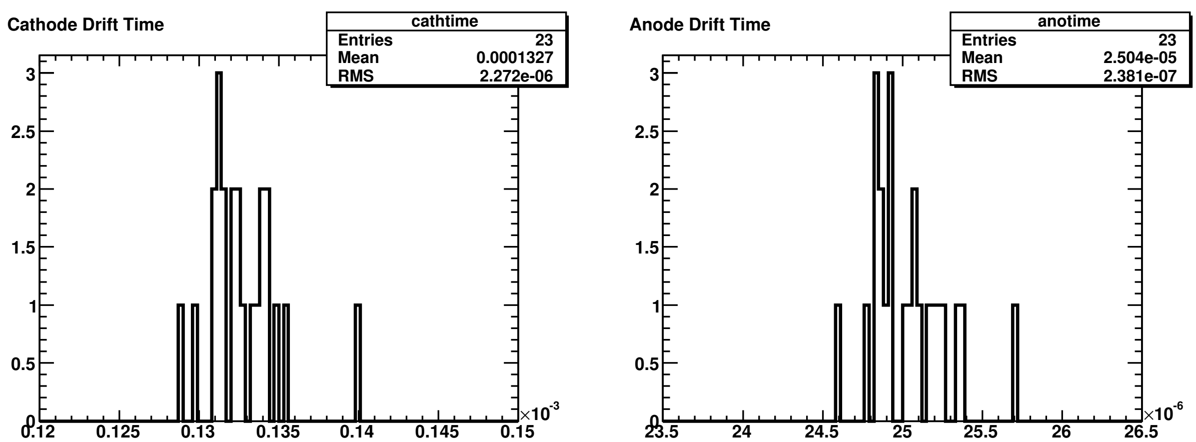

Figure 3: Distributions of cathode drift time and anode drift time using the modified purity monitor module.

Even though we see the same disparity between the measurement and the calculation using the modified module, it is good to see that the results using the modified module are very consistent with those using the default module. It is possible that the highly simplified calculation does not represent the reality. The electrons will induce currents on the anode before they reach the anode grid. One may have to work out the detailed field before and after the anode grid in order to understand the electron drift time.

One advantage of the modified module is that it can supply an independent voltage to the anode. We can vary the anode voltage to optimize the performance of the purity monitor.

References

[1] E. Aprile, K. L. Giboni and C. Rubbia, Nucl. Instrum. Meth. A **241**, 62 (1985).