東北大学機関リポジトリ
TOUR
Tohoku University Repository

Development of Low-Pressure MWPC

著者	Ozeki K., Otsu H., Okuda T., Watanabe K., Yakushiji T., Iwasa N., Kobayashi T.
journal or publication title	CYRIC annual report
volume	2001
page range	35-38
year	2001
URL	http://hdl.handle.net/10097/30113

I. 7. Development of Low-Pressure MWPC

Ozeki K., Otsu H., Okuda T., Watanabe K., Yakushiji T., Iwasa N., and Kobayashi T.

Department of Physics, Tohoku University

We have been engaged in developing Low-Pressure MWPC which can be used with less influence of multiple scattering by chamber gases. A practical application of the device is to measure the position of secondary beams at a momentum dispersive focal plane. It is necessary to decide the momentum for each particle in experiments using secondary beam with momentum deviation. A typical momentum dispersion is about ±3 %. One of the way to decide the momentum is to measure the time of flight between timing counters. This method has a disadvantage for large γ particles, which make the momentum resolution worse. In contrast, measurement of the position with high accuracy at momentum dispersive focal plane enables us to decide the momentum of each particle with wide energy range. Low-Pressure MWPC is designed as the focal plane detector. In addition to gas itself, low pressure property allows us to reduce the amount of substance of window foils separating MWPC and vacuum of about 10^{-6} Torr of secondary beam line. In developing, the following requirements are taken into account:

$Z \geq 1$,

Kinetic energy: $T \approx 250$ MeV/A (about two times larger than energy loss of the minimum ionizing particles),

Counting rate: 1-10M Hz/plane.

MWPC operates less stably when used at low pressure because of discharge. Until now, it was confirmed that efficiency of nearly 100 % could be achieved for minimum ionizing particles (β ray from ^{90}Sr) under 100 Torr by using pure i-C_4H_{10}. It is expected that the usage for particles which have larger energy deposit than minimum ionizing particles makes operating HV and pressure low. In order to confirm this expectation and to examine whether it could maintain high enough efficiency at high counting rate, we investigated operating characteristics using 70 MeV protons (about 5.7 times larger than energy loss of the minimum ionizing particles). Hit patterns and time spectra of MWPC were measured by multi-hit TDC LeCroy LRS3377, via pre-amplifier REPIC RPV-041 and amplifier/discriminator card LeCroy 2735PC. The threshold of 2735PC was set to 5 V.

Operating characteristics were measured at various pressures as follows: 760, 380, 190, 100, 80, 60, 40, 30, 20, 10, and 5 Torr. Efficiency curves are shown in Fig. 1. It can be seen that efficiency curve shifts to lower voltage when the pressure becomes low. Fig. 2 shows optimum voltages at each pressure (for comparison, those for β rays are also shown). Optimum voltage decreases sharply under 40 Torr in contrast to gentle dependence at higher pressure. In order to interpret the relation between pressure and optimum voltage, we made a model from several assumptions as follows:

(1) Translate the condition that efficiency reaches 100 % into the condition that the number of electrons which arrive at an anode wire per event always reaches a constant value (N),

(2) The number of seeds is in proportional to pressure (eP, e is a constant),

(3) Divide the electric field into two parts: the cylindrical field near anode wires and the constant field distant from anode wire, namely

$$E = d\frac{V}{r} \quad \text{if} \quad r \le \frac{s}{\pi},$$

$$E = d\frac{\pi V}{s} \quad \text{if} \quad r \ge \frac{s}{\pi},$$

where s is the anode wire spacing and d is a constant which is decided from the geometry of MWPC¹⁾. The intermediate field is not considered here. An expression formulated by Aoyama²⁾ is used here as the first Townsend coefficient:

$$\frac{\alpha}{P} = KS^m \exp\left(-LS^{m-1}\right),$$

where $S=E/P$, K, L, m are constants ($0 \le m < 1$). If a is the anode wire radius and b is the (averaged) starting point of the avalanche, relation between pressure P and optimum voltage V is expressed as

$$\frac{KdV}{L(1-m)}\exp\left\{-L\left(\frac{dV}{aP}\right)^{m-1}\right\} - \left\{\frac{KdV}{L(1-m)} - PK\left(\frac{d\pi V}{sP}\right)^{m}\left(b-\frac{s}{\pi}\right)\right\}\exp\left\{-L\left(\frac{d\pi V}{sP}\right)^{m-1}\right\} - \ln\frac{N}{eP} = 0.$$

The best fitting result for measured values is shown as solid lines in Fig. 2. The model fitting result succeeds in reproducing the measured points except the knee shape around 60

Torr. This difference around the knee point is expected to be improved by introducing intermediate field into the model. The model which includes only cylindrical field cannot reproduce sharp decrease at lower pressure. This result suggests that avalanche occurs not only in the region near the anode wires, but also in the outer region because of the increase of reduced field *S*.

The responses for high counting rate were measured. The rate dependence of the efficiency was measured at 190 Torr. The counting rates per about seven wires limited by a collimator installed were changed as follows: 1k, 10k, 100k, 1M, and 2M Hz. TDC spectra at 1k and 2M Hz are shown in Figs. 3 and 4, respectively. At 1k Hz, the component of wire multiplicity 1 occupies the greater part of all components, of which efficiency reaches practically almost 90 %. At 2M Hz, to the contrary, accidental events having same period with RF frequency increase. These accidental events make multiplicity 1 events not so. "Effective" efficiency was obtained by applying timing gate on TDC spectra to remove the accidental events. The location of gate is much the same as that of spectrum of wire multiplicity 1. Efficiencies with/without timing gate as a function of counting rate are shown in Fig. 5. Total efficiency keeps nearly 100 %, while efficiencies of wire/cluster multiplicity 1 decrease remarkably in the case without timing gate. On the other hand, efficiencies with timing gate hardly decrease even at high rate up to 2M Hz/7 wires. From this result, it was found that operation for high counting rate showed useful enough operating characteristics.

From these measurements, the feasibility of Low-Pressure MWPC on secondary beam line was confirmed. This device will be used practically at facilities such as HIMAC at NIRS, RIBF at RIKEN.

References

1) F. Sauli, PRINCIPLES OF OPERATION OF MULTIWIRE PROPORTIONAL AND DRIFT CHAMBERS.
2) Aoyama T., Nucl. Instr. and Meth. A **234** (1985) 125.

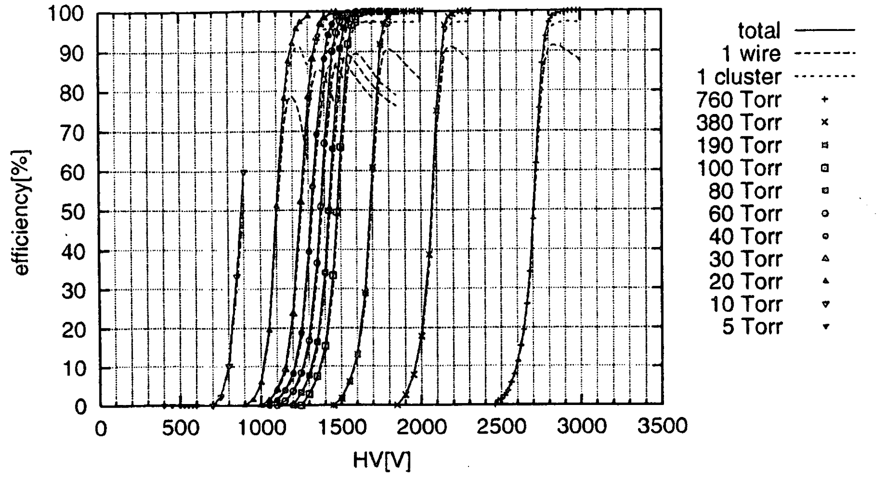

Fig. 1. Efficiency curves for protons at various pressures.

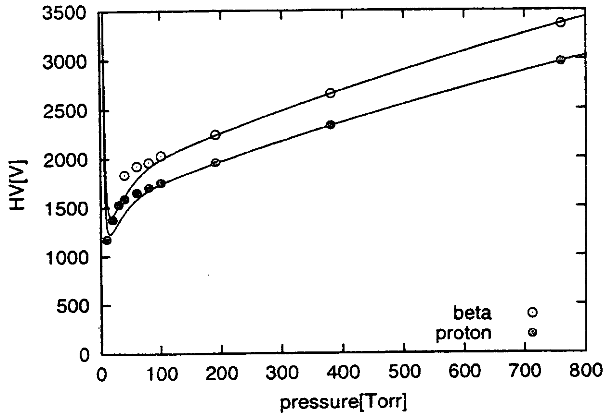

Fig. 2. Optimum voltage for protons and β rays at each pressure and model fitting result.

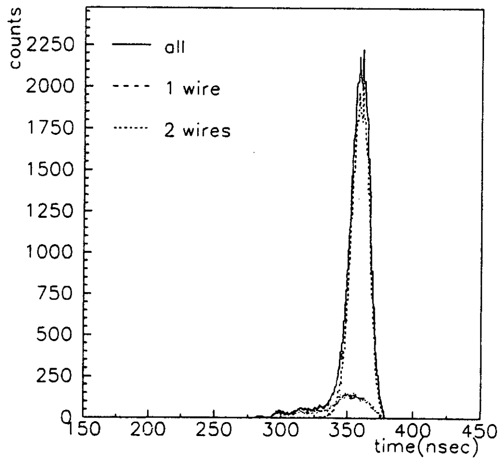

Fig. 3. TDC spectrum at 1k Hz.

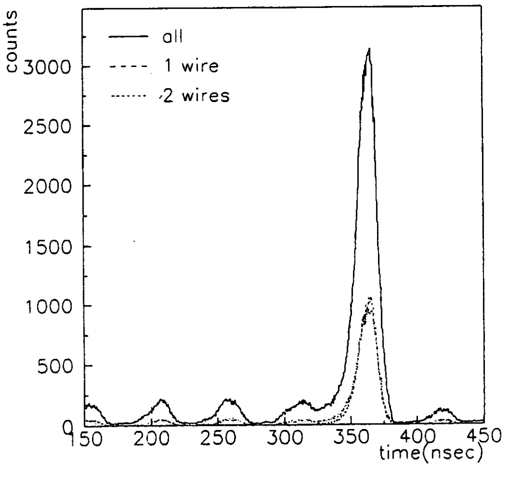

Fig. 4. TDC spectrum at 2M Hz.

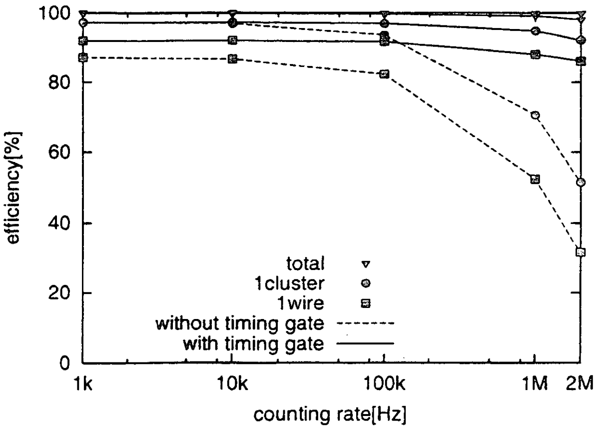

Fig. 5. Efficiencies with/without timing gate as a function of counting rate.