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Need for Dynamic Control of the High Voltage Supply for the GEM Strip Chamber Muon Detector

Roy Weinstein
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January 9, 1993

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Based upon the dependence of resolution on pulse height, and hence on HV x T/P, we conclude that a dynamic feedback HV control is required for proper operation of strip chamber technologies.

GEM Technical Note

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1. Resolution Stability

From data reported to the GEM muon group meeting on strip chambers, on 1/8/93, a 50 Volt change in the high voltage of 2,600 Volts (i.e., 1.92%) caused a change in resolution from 70 μm to 105 μm in the MWPC prototype (i.e., 50%).

In the open profile prototype, a 100 Volt change in the high voltage of 3,300 Volts (i.e., 3.03%) caused a change in resolution from 56 μm to 72 μm (i.e., 29%).

Both sets of data were in the interval ± 6°.

The resolution instability factor due to high voltage:

$$f \equiv \frac{\Delta\sigma}{\sigma} \Big/ \frac{\Delta HV}{HV}, \qquad \text{Eq. 1}$$

is therefore measured to be:

	SPC	MWPC
f	9.5	26

Thus, we see from the prototype data that

$$\frac{\Delta\sigma}{\sigma} \geq 9.5 \frac{\Delta HV}{HV}.$$

Let us assume that a resolution of 65 μm is observed, and that a resolution of 75 μm is indeed desired. The maximum increase in σ should then be held to 10 μm (a 15.3% change). Then the maximum change in high voltage should be limited to 15%/9.5 = 1.6%.

The resolution σ will depend on HV due to gas gain, even if no other high voltage effects are present. The resolution, to first order is σ = noise charge/pulse charge. The pulse charge is of course high voltage dependent. i.e., Gas Gain = f(HV). In fact, the resolution sensitivity in the SPC geometry is not inconsistent with being due to gas gain alone.

However, more generally gas gain depends on

$$Gas\,Gain = f\left(\frac{HV \times T}{P}\right) \qquad \text{Eq. 2}$$

We use the SPC results, and attribute the factor f entirely to gas gain.

In this case the temperature, pressure and HV for the chambers should satisfy:

$$\Delta HV/_{HV} + \Delta T/_{T} - \frac{\Delta P}{P} \leq \frac{15\%}{9.5} = 1.6\% \qquad \text{Eq. 3}$$

If we used the value of f reported for the MWPC chambers, Eq. 3 would be about three times more stringent. However, it is unlikely that all of the value of f for the MWPC geometry can be attributed to gas gain alone.

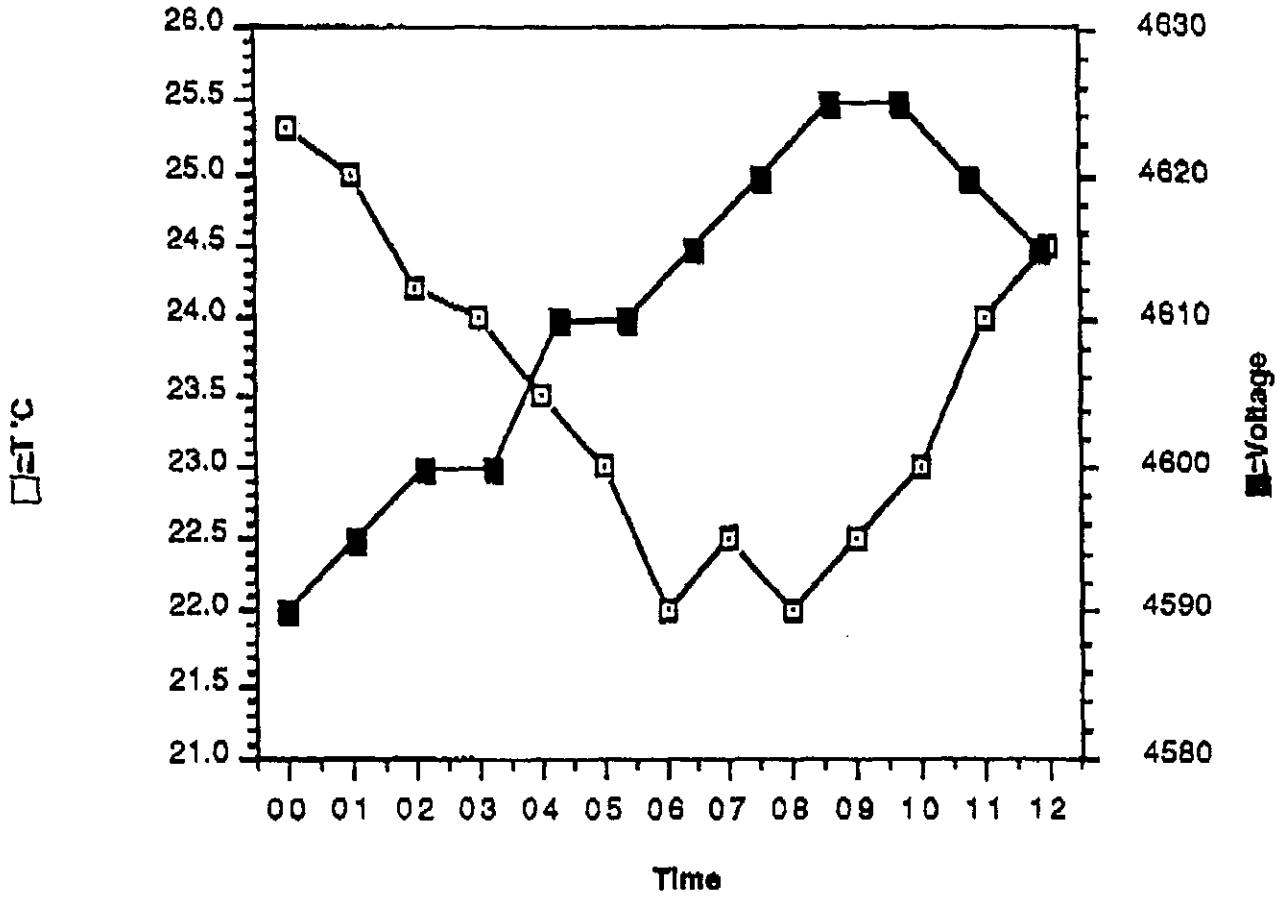
Storms can vary P by 3%. Ordinary temperature control systems allow $\pm 2°$ F = 1.1° C ~ 0.4%. Even the temperature *gradient* in a device the size of GEM may exceed 0.4%.

It appears prudent to plan on a dynamic high voltage control for the GEM muon strip chambers. Such a control would feedback a measure of gas gain to the high voltage supplies, in order to keep gas gain constant.

Experiments at CERN have used such systems successfully. Fig. 1 shows for example a temperature profile and controlled HV profile taken

during development of the dynamic HV control for SMC. At the stage shown, there was a 2 - 3 hour lag between the temperature profile and the HV response, due to location of temperature sensors ,and response time of the feedback system. In general such systems work well once debugged.

Time vs Temperature & Controller Voltge on 8-21-92



Note: The Pressure was constant at 975 mbar during this time.

Parks 8-21-92

Fig 1