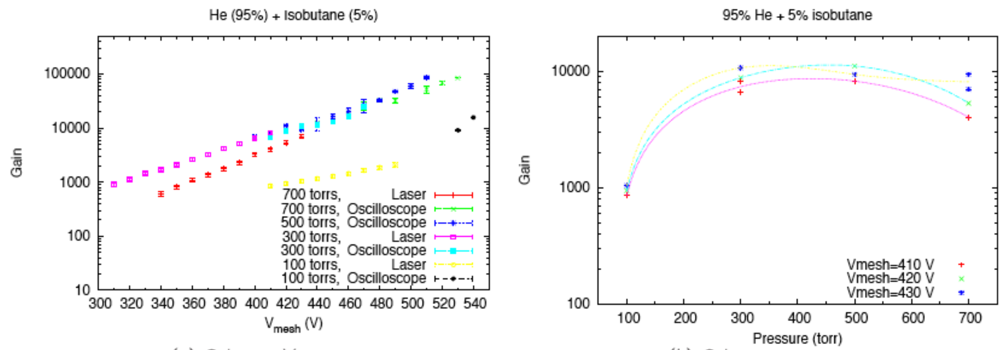
Specifications for pressure stability for the gas regulation system.

❖ Gain variation as a function of the gas pressure



(a) Gain v.s. V_{mesh} (b) Gain v.s. pressure

Figure 5: Gain as a function of pressure and V_{mesh} for the 95% He + 5% Isobutane mixture.

As one can see only in the low pressure region there is a strong dependence of gain.

Order of magnitude:

Factor 10 for dp/p = 1; resolution of micromegas about 1%; so dp/p giving a change of 1% corresponds to dp/p = 0.1% or dp~0.1mbar

❖ Simulations for He+CO_2

Gas properties were simulated for the He+CO_2 mixture. We used the code magboltz, where the Penning effect was taken into account. The ionization (aka Townsend) coefficient (α) [1/cm] was obtained and translated to the gain (g) using the equation $g = 2^{L\alpha}$, where L denotes the gap between the cathode and the anode. We employed 128 μm as L.

We estimated the gain fluctuation due to the uncertainties of (a) the total gas pressure (p_{tot}) and (b) the partial pressure of He (p_{He}), respectively.

- Fluctuation due to the total pressure

  The change of p_{tot} primarily alters the Townsend coefficient α, but it also changes the gas density inside the gap. We can effectively take into account the latter effect by changing the gap size; $L(p_{tot}) = L_0 * (p_{tot} + \delta p_{tot})$.

  In general, the Townsend coefficient α is nearly proportional to E/p_{tot}. On the other hand, $L(p_{tot})$ is proportional to p_{tot}. The number of ionization collision Lα then remains almost unchanged because p_{tot} is cancelled between L and α, implying that the gain is rather stable with respect to p_{tot}.

  The gain was calculated for different p_{tot} of 1, 0.5 and 0.2 atm, respectively (Fig. 1). The fluctuation of the gain was estimated for the respective cases by changing the total pressure by +1%. As shown in Fig. 2, the resultant fluctuations are less than +-5%.

- Fluctuation due to the partial pressure of He

The simulated gains for 10% CO2 and 11% CO2 are shown in Fig. 1. The gain fluctuation was deduced based on the following equation;

$\delta g/g = (1 - g(10\%\ CO_2)/g(11\%\ CO_2))$ at a given $E/p_{tot.}$

The results are shown in Fig. 2. For the 1% accuracy of p_{He} with respect to p_{tot}, the magnitude of the gain fluctuation is about 30% at maximum.

Hence the gain fluctuation is dominated by the accuracy of the partial pressure of He. If the gain fluctuation is to be less than 1%, the partial pressure should have an accuracy of 0.03% with respect to the total pressure.

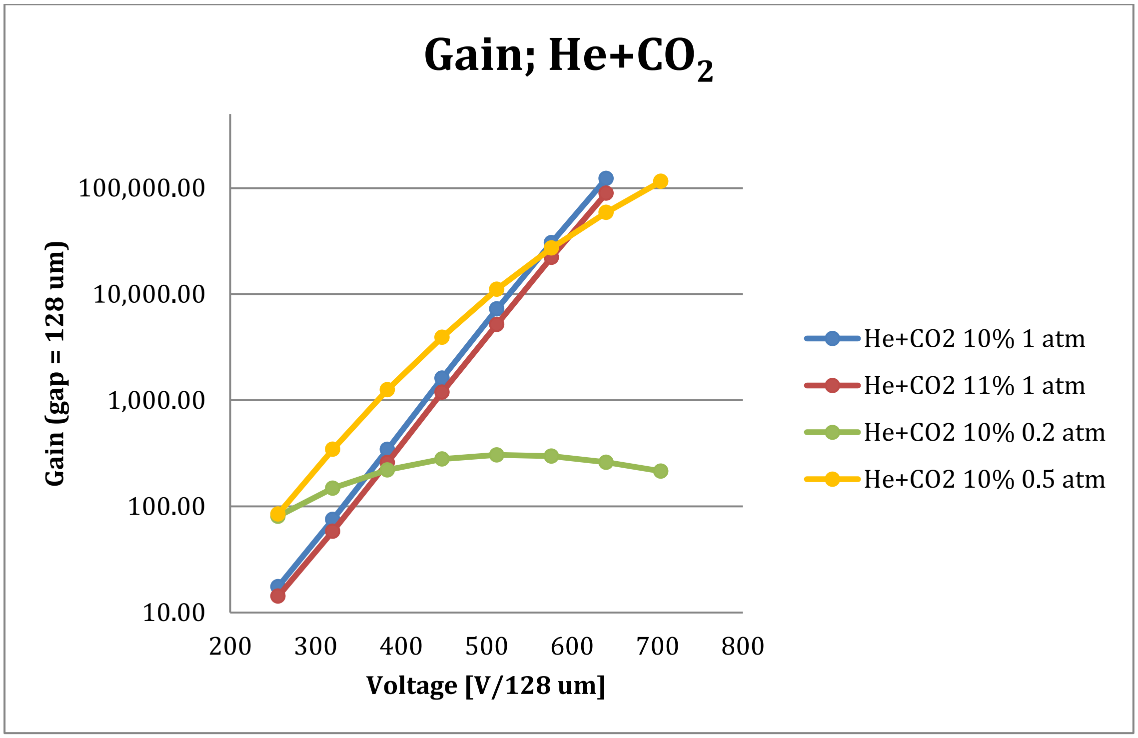


Figure 1: Simulated gain as a function of the field gradient.

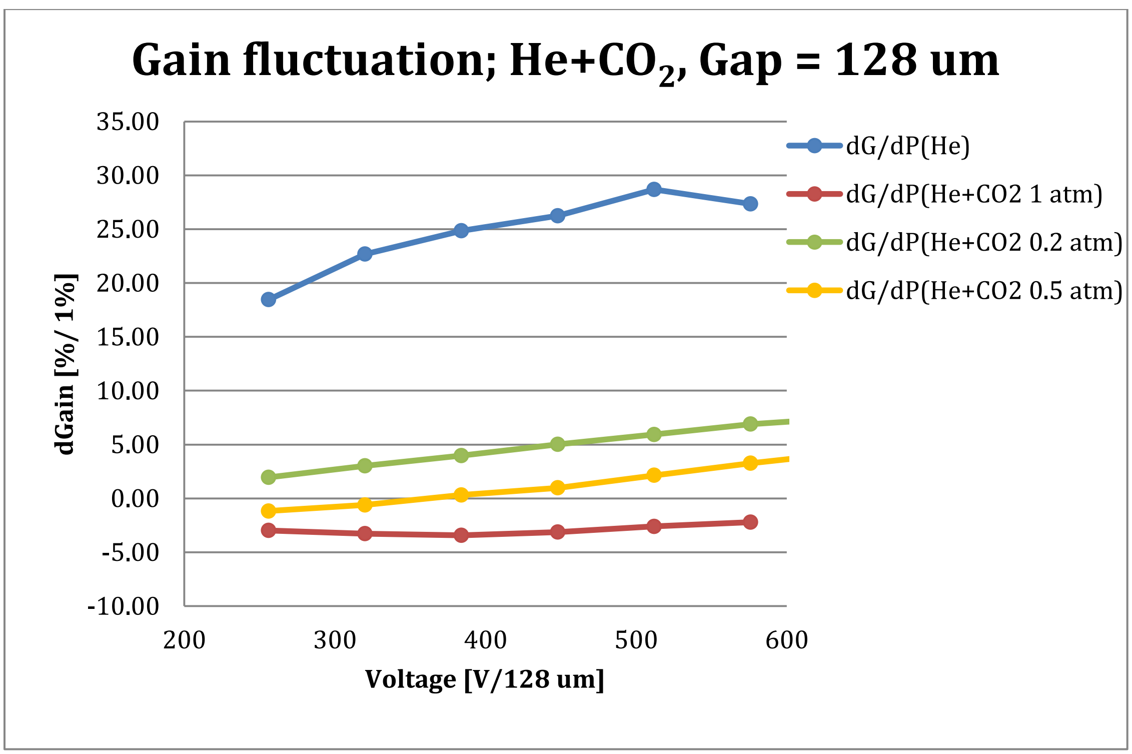
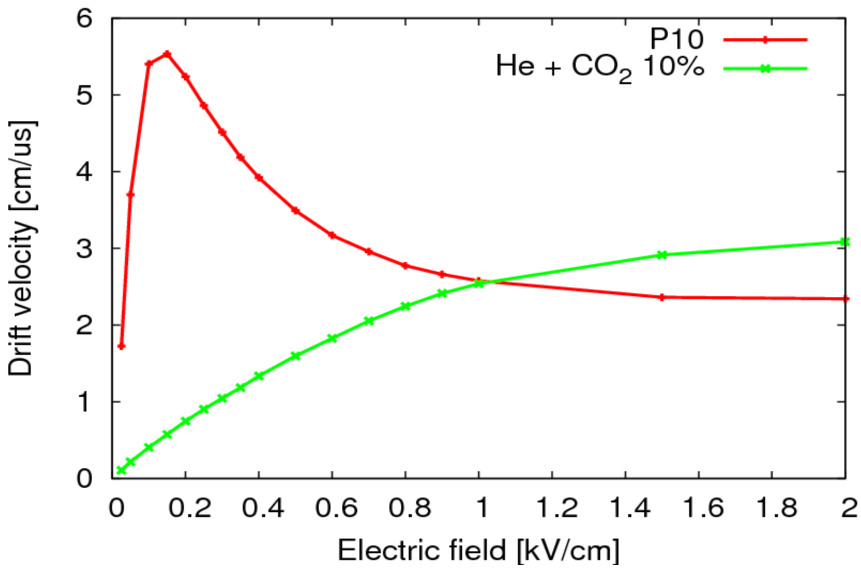


Figure 2: Gain fluctuation for (Blue) the partial pressure of He and (Red) the total pressure of He+CO_2

❖ Drift-time as a function of the pressure

Variations of drift-time as a function voltage/pressure will be monitored by the Laser system. As example we may consider the figure below:



In the case of P10 one will work the maximum, where dependence is small. For the He+CO_2, we want to work in the region 1kV/cm. For order of magnitude we have:

To good enough approximation, the drift velocity is proportional to the V, this is inversely proportional to p; in the middle of the detector, there drift time is ~50 cm/2(cm/μs) = 25 μs; if we want a stability of 100 μm, the drift time must be stable to 0.1/500=2/10,000 = 0.02%; so dv/v~2/10,000 or dp/p = 2/10,000. if p = 100 mbar, dp = $2*10^{-2}$ mbar=20 μbar; this is close to the value given by Ana.

❖ Simulations for He+CO_2

The simulated electron drift velocity is plotted for different mixtures of 10% CO2 and 11% CO2, respectively, in Fig. 3. The fluctuation of the velocity was calculated for the case wherein the partial pressure of He or the total pressure of He+CO_2, respectively, changes by 1%. The results are shown in Fig. 4.

For the pressure accuracy of 1%, the magnitude of the velocity fluctuation is about +-2% at maximum around E = 1 kV/cm/atm, which is again governed by the accuracy of the partial pressure of He. A pressure accuracy of 0.01% yields a velocity fluctuation of less than +-0.05%.

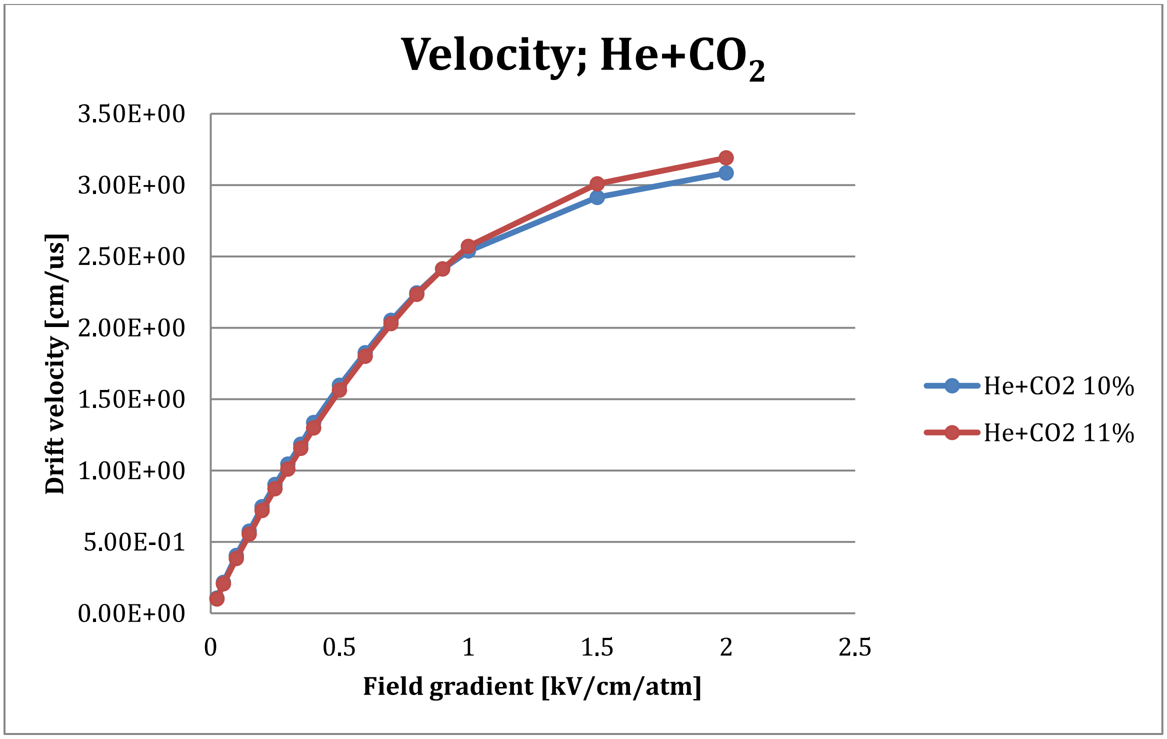


Figure 3: Simulated velocity of the electron drift.

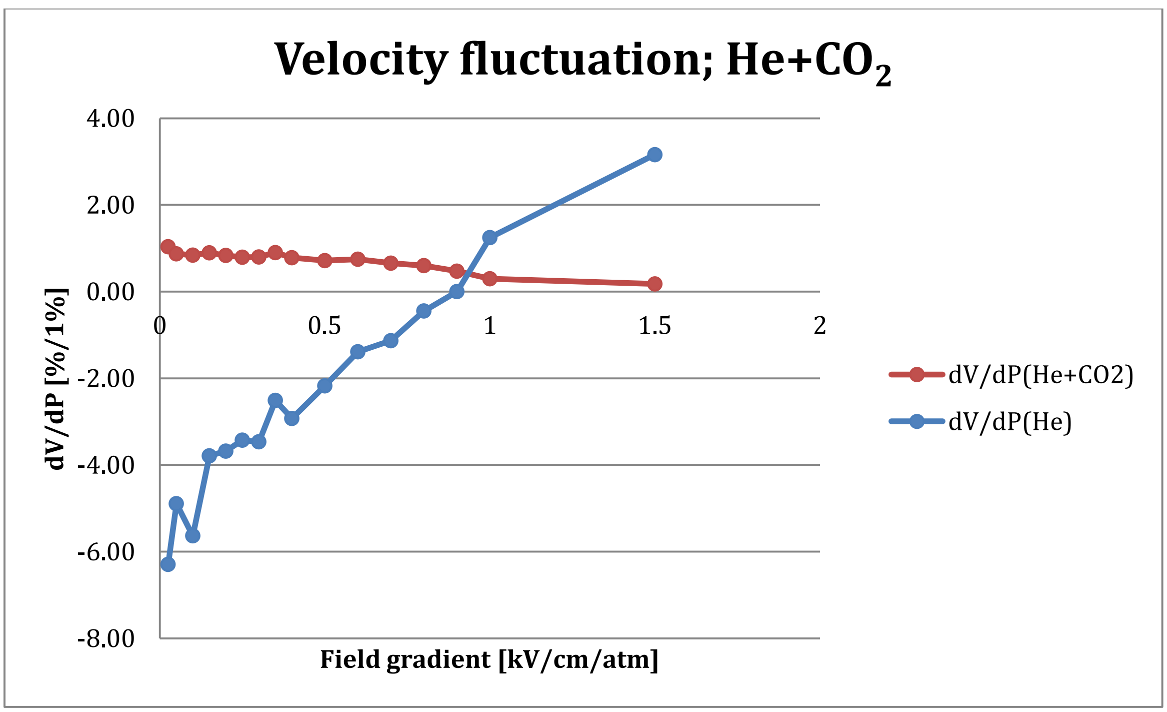


Figure 4: The fluctuation of the electron drift velocity for (Blue) the partial pressure of He and for (Red) the total pressure of He+CO2

❖ Conclusion

The gain fluctuation is dominated by the partial pressure of He (p_{He}). A 0.03% accuracy of p_{He}, with respect to the total pressure, gives a gain fluctuation of 1%.

The drift velocity is dominated again by p_{He}. Given a 0.01% accuracy for p_{He}, the magnitude of the velocity fluctuation is less than +-0.02% around E = 1 kV/cm/atm. The drift velocity will be monitored by a laser.

It should be examined if the pressure stability of 100 μbar (0.1% of 100 mbar) would result in a considerable cost decrease compared to that of 10 μbar (0.01% of 100 mbar). Otherwise one should adopt the value of 10 μbar as given by Ana.

❖ Appendix

The simulated gain was compared to the result obtained in the test bench of NSCL. The simulation well agrees with the measurement.