Ultra-Light Gas Mixtures for Drift Chambers

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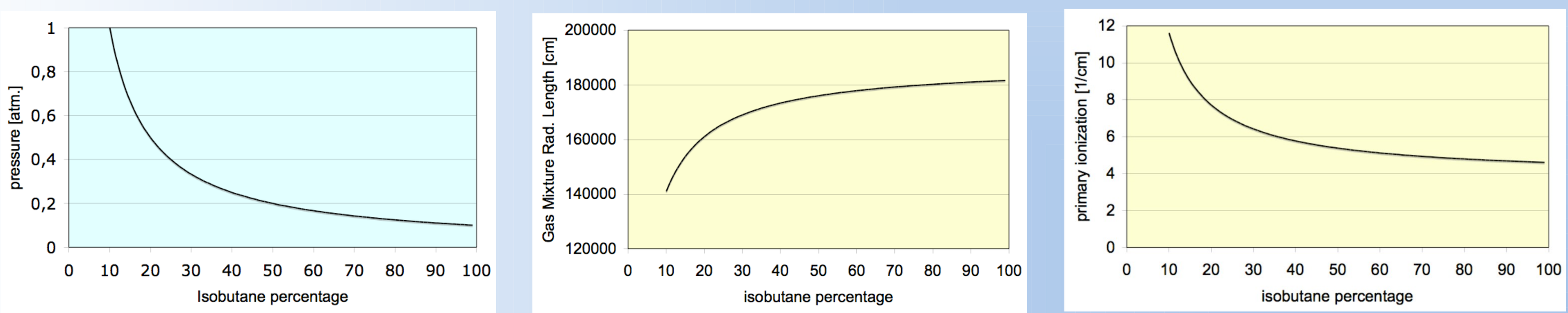
ABSTRACT

We present results on the measurements of gas gain for gas mixtures at absolute pressure below the atmospheric pressure, down to 100 mbar, and their relative stability.
Besides the obvious advantage of further limiting the contribution to the momentum measurement due to multiple scattering, the operation at low pressure allows for a fine tuning of the working parameters of a drift chamber like drift velocity, diffusion and specific ionization.
Furthermore, such a possibility is of particular interest for experiments like the direct muon to electron conversion experiment Mu2e at Fermilab, where the tracking detector needs to operate in vacuum.
Plans for extending the measurements to transport parameters, like drift velocity and diffusion, will also be presented.

Introduction

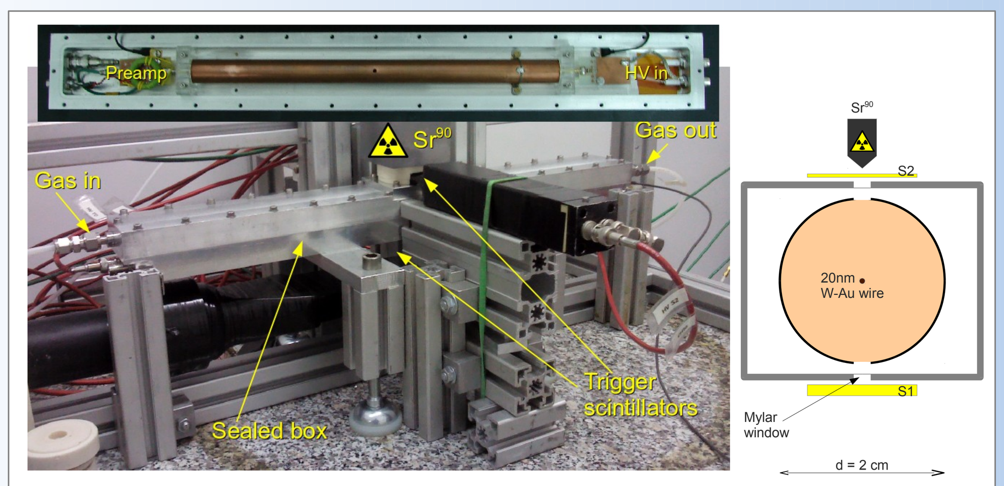
The choice of gas mixture in a drift chamber is of utmost importance, particularly for experiments where the trajectories of low momentum particles need to be reconstructed with great accuracy. The use of helium based gas mixtures may not be sufficient to overcome the limitations due to the multiple scattering contribution.



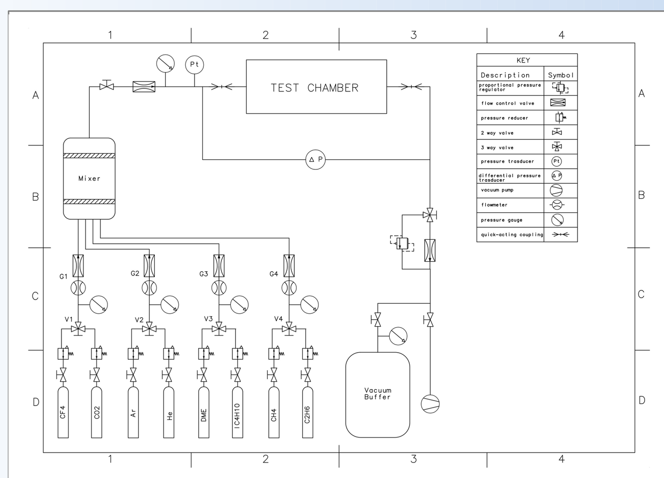
Variation of several quantities as a function of the isobutane fraction (keeping the partial pressure P_{IB} constant)

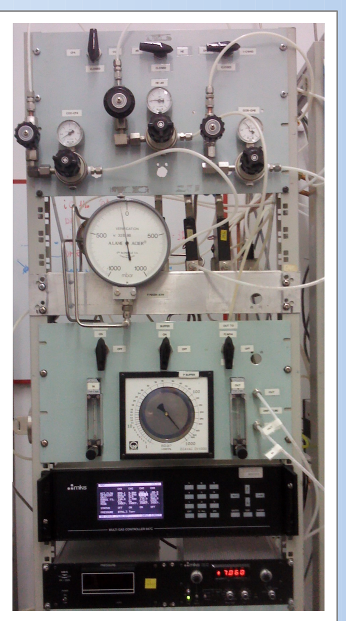
Moreover, for experiments like Mu2e at Fermilab, where the tracking detector is immersed in vacuum, a gas mixture at lower than atmospheric pressure helps reducing the vessel thickness, reducing the amount of material on the path of the conversion electrons, harmful both for the multiple scattering contribution to the momentum measurement and for the fluctuations of the energy loss.
To this purpose we have successfully tested some helium based mixtures at pressures below the atmosphere for proportional mode operation, confirming the good stability, in terms of both efficiency and gain, down to values of 0.1 atm.

Experimental apparatus



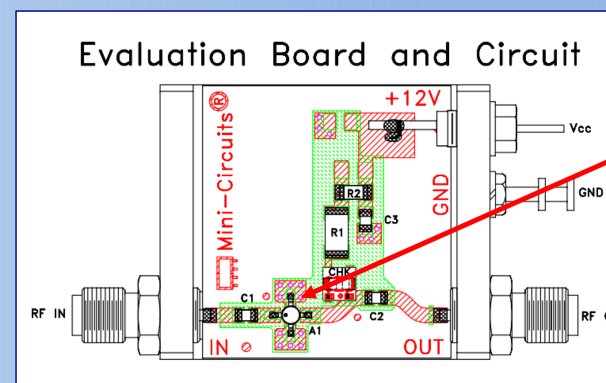
The test tube is hosted in a vacuum proof aluminum box with two thin mylar widows to allow beta electrons from a Sr90 source and X-rays in.

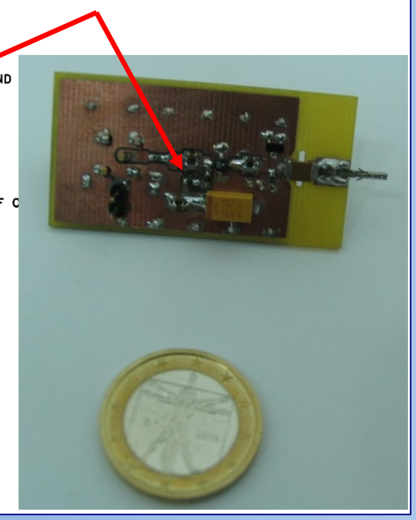




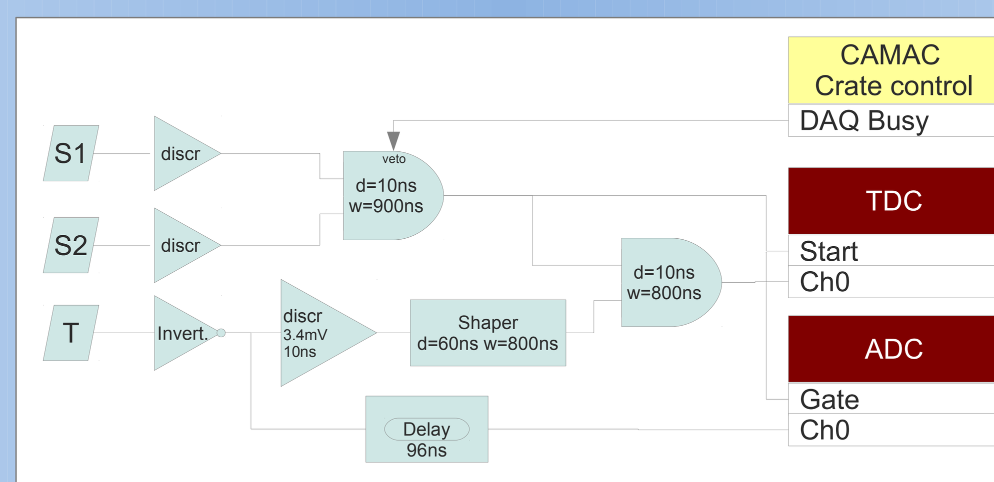
Mixture composition set by mass flowmeters. Pressure set with proportional valve to 0.1 Torr.

Experimental apparatus



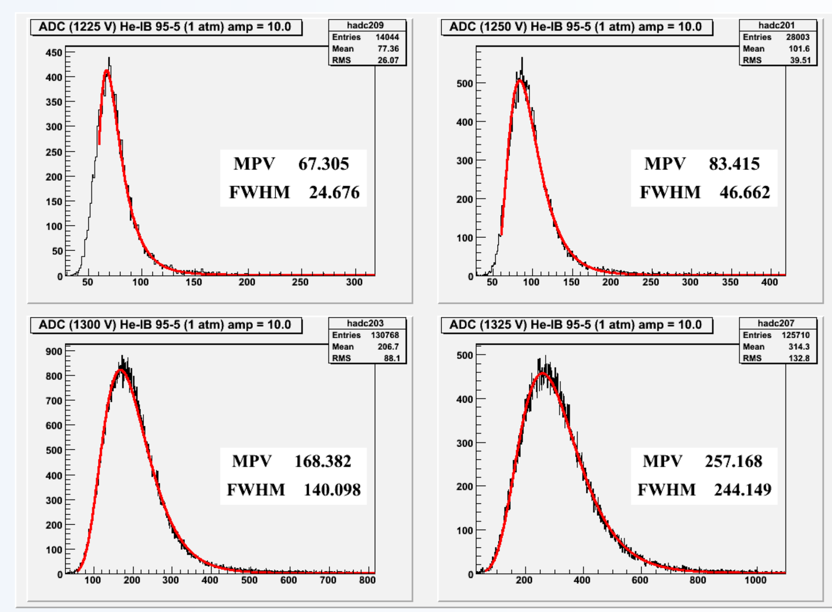


A preamplifier based on the MAR-6 chip with a gain of 20dB is connected to the tube and hosted in the pressure box.

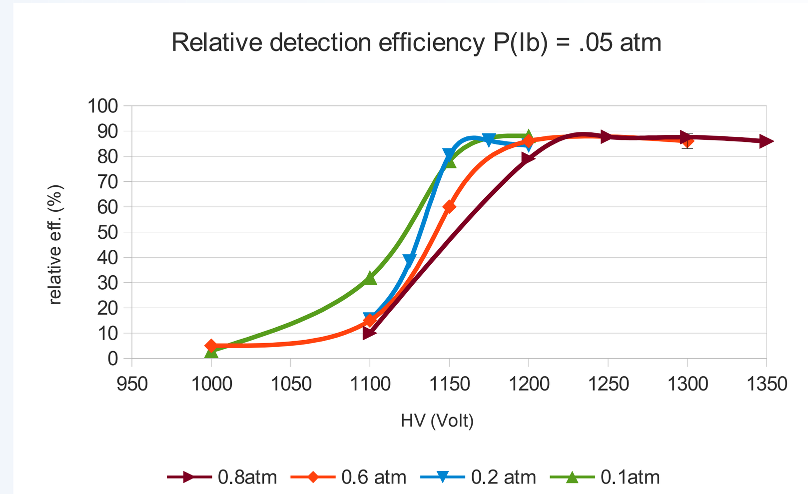


The acquisition is triggered by the coincidence of the two scintillators. The TDC signal is only used for cross checking purposes in this study.

Results

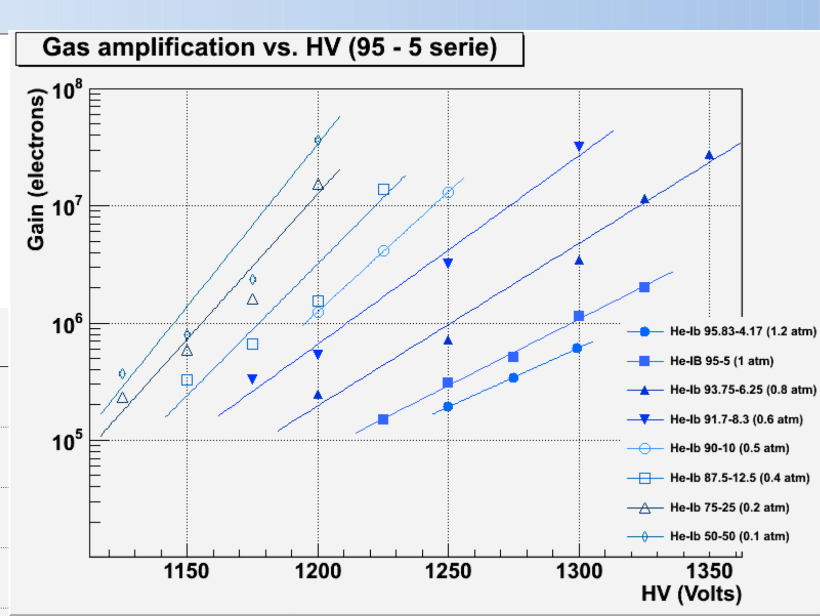


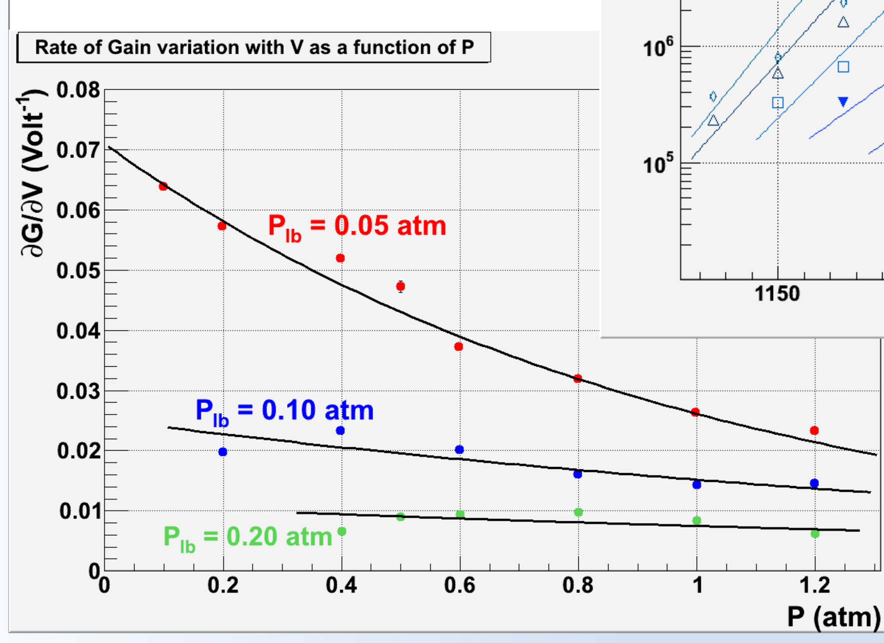
(top) Example of several ADC distribution for P^{IB}=0.05atm, P = 1atm.
(bottom) The relative efficiency vs. HV is ploted for several pressures ranging from 0.8 to 0.1 atm.



Gain

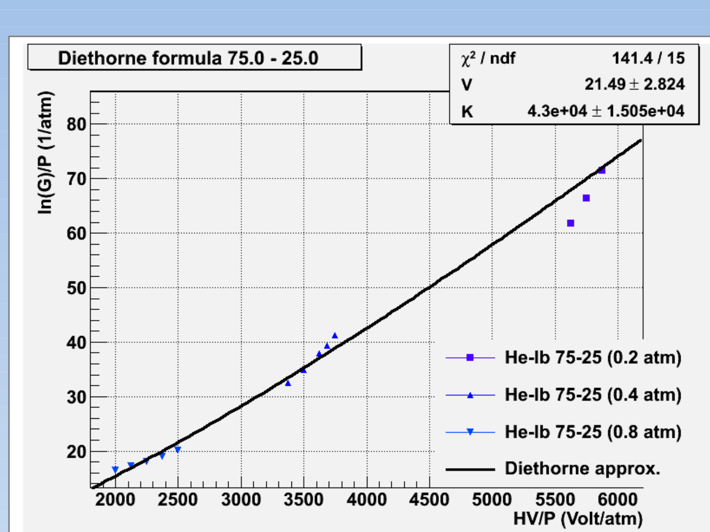
(right) Gain variation vs V for different P at P_{Ib} = 0.05 atm





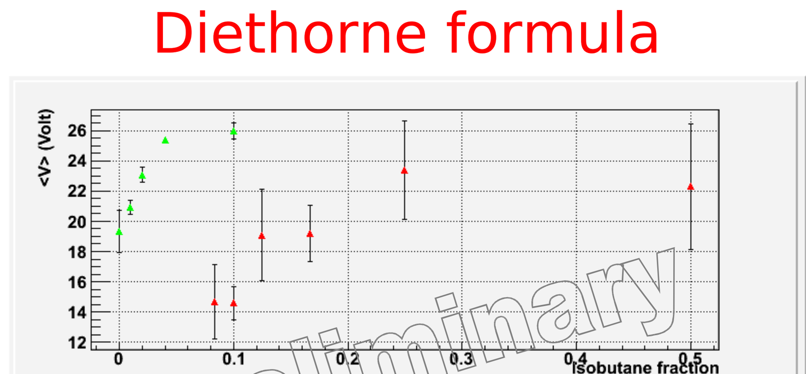
(left) Rate of gain variation with V as a function of P for different He/Ib mixtures.

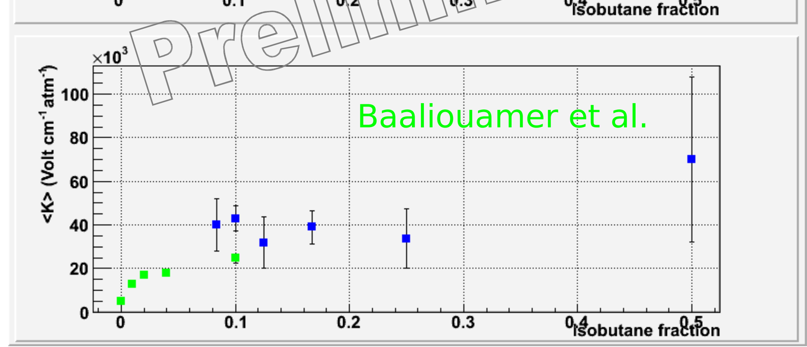
Results



Results of the fit with Diethorne formula [1]. Our parameters are compared with those of Baaliouamer et al. [2]

Diethorne formula





We have studied the gain variation as a function of applied voltage for several gas mixtures and pressures ranging from 0.1 to 1.2 atm.
The range of stability at lower pressures is narrowed to about 100V in the case of P_{Ib}=0.05 at 0.1atm
The data have been fitted using Diethorne's formula in order to estimate the <V> and <K> coefficients.
We are evaluating the discrepancy with Baaliouamer et al. [2] results and we plan to further extend our measurements.

References:
[1] W. Diethorne, US.AEC Report NYO. 6628 (1956)
[2] M. Baaliouamer et al. NIM A 328 (1996) 490-494
[3] V. Golovatyuk et al. NIM A 394 (1997) 97-102
[4] P. Bernardini et al. NIM A 355 (1995) 428-433
[5] V. Golovatyuk et al. NIM A 461 (2001) 96-97

Work in progress

We plan to measure the transport parameters (drift velocity, diffusion and attachment coefficients) and primary ionization of a number of He based gas mixtures by using the setup described in [3, 4, 5] in conjunction with cluster counting electronics (see Pepino's contribution to this conference).
We are also planning to extend our measurements to mixtures using metane, etane, DME and hydrogen free gas molecules (CO_2 and CF_4) for operation in heavy neutron backgroud environments