Electron drift velocity measurements at high electric fields.

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Abstract

A method to measure the electron drift velocity is presented. A pulsed UV Nitrogen laser is used to excite both the drift and cathode Nickel micromeshes of a Micromegas detector. The signals induced on the anode are then readout by a fast current amplifier. Several results have been obtained for various gas mixtures and electric fields from 10 V/cm to 14 kV/cm. Relevant applications with low (TPCs mode) and high (pre-amplification mode) electric fields will be discussed.

1 Introduction

In several applications of gaseous detectors it is important to know the electron drift velocity in gas. With a very simple device based on the Micromegas principle [1], measurements are performed in different gas mixtures. Results are presented for a wide range of electric fields.

2 Setup description and measurement principle

The setup is based on a standard Micromegas detector used in a double photodetector mode [2]. The cathode micromesh is the first photon converter and on top of it another mesh is used as a second photon converter and drift electrode. A scheme of this setup is given in the figure 1.
The photon source is a UV (λ=337 nm) pulsed laser (N_2), focalised through a lens in order to increase the photo-electric effect on the two meshes. Two signals are induced on the grounded anode (see figure 2) which is read through a

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fast preamplifier (1 GHz): one for the photo-electrons created on the drift electrode and one for the photo-electrons created on the cathode mesh. Since the distance between the two electrodes is known, the time delay between these two signals provides the electron drift velocity in the conversion gap. This measurement has been made for several conversion field values in different gas mixtures: Argon, Neon or Helium with Isobutane or CF_4 as quencher.

3 Calibration measurements

A first set of measurements were made in well known gas mixtures to check the method. Some results obtained in Helium mixture, P10 (Argon + 10% CH_4) and pure CH_4 are represented in the figures 3, 4 and 5 and compared with published measurements [3–5] and with Monte-Carlo calculations performed with Magboltz [6]. The agreement is quite good.

4 Results in several gas mixtures and for different purposes

4.1 Pre-amplification mode in Micromegas

The pre-amplification mode is a nice solution for Micromegas to cope with hadron fluxes as it has been shown in [7]. Different gases (Argon, Neon, Helium) with small amount of quencher (Isobutane or CF_4), which can provide a comfortable pre-amplification gain, are studied here in order to find gas mixtures which allow a high enough electron drift velocity. Results are presented in figures 6, 7 and 8. Neon-based mixtures are attractive, both for their preamplification factor and for the high drift velocity they allow to reach (greater than 5cm/μs). For instance in Ne + 5% iC_4H_{10} the pre-amplification mode starts at 2.5 kV/cm and the drift velocity reaches 5 cm/μm for 3.6 kV/cm while in Ar + 5% iC_4H_{10} it starts at 6 kV/cm and the higher velocity is about 4 cm/μs.

4.2 Interest for Time Projection Chamber

Gas mixtures for TPC should allow a high electron drift velocity at very low electric fields. A drift velocity higher than 5 cm/μs can be reached in CF_4 mixtures for fields as low as 200 V/cm (fig. 9). The advantage of such a gas is obvious compared to quenchers like CO_2 (fig. 10). As a comparison, the drift velocity reaches a maximum of 4 cm/μs at 400 V/cm in Ar + 5% CO_2 while it reaches a maximum of 9 cm/μs at 250 V/cm in Ar + 5% CF_4.

4.3 Small drift and high flux

Some measurements have been made to find the best gas mixture in order to cope with high particle fluxes and allow high gain and good time resolution. Adding a small fraction of CF_4 in Neon leads to a dramatic increase of the electron velocity (fig. 11). The results obtained with the gas mixture used for the Micromegas tracker of the COMPASS experiment [8] are also represented on the figure 12.

5 Conclusion

The feasability of a simple device to measure electron drift velocities in a wide range of electric fields, based on the Micromegas detection principle, has been demonstrated. There is a good agreement with previous published results and simulations. Drift velocity measurements are presented in various gas mixtures. The experimental results at very high field are of great interest for some applications and could be used to improve the accuracy of Monte Carlo simulations.

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[8] CERN/SPSLC 96-14 SPLSLC/P297 and CERN/SPSLC 96-30 SPLSLC/P297 add.1.

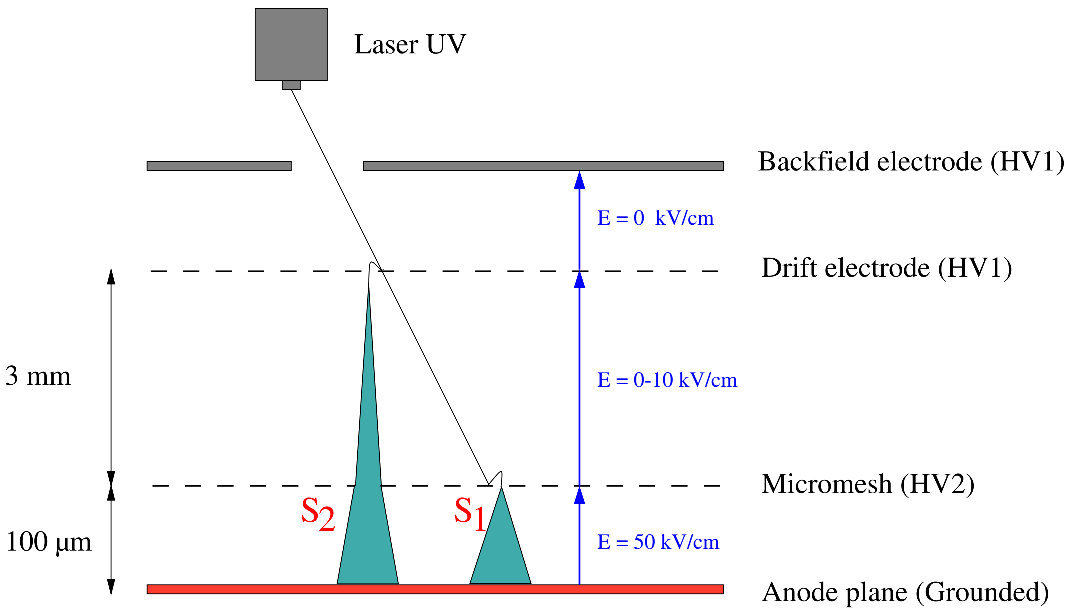

Fig. 1. Experimental setup.

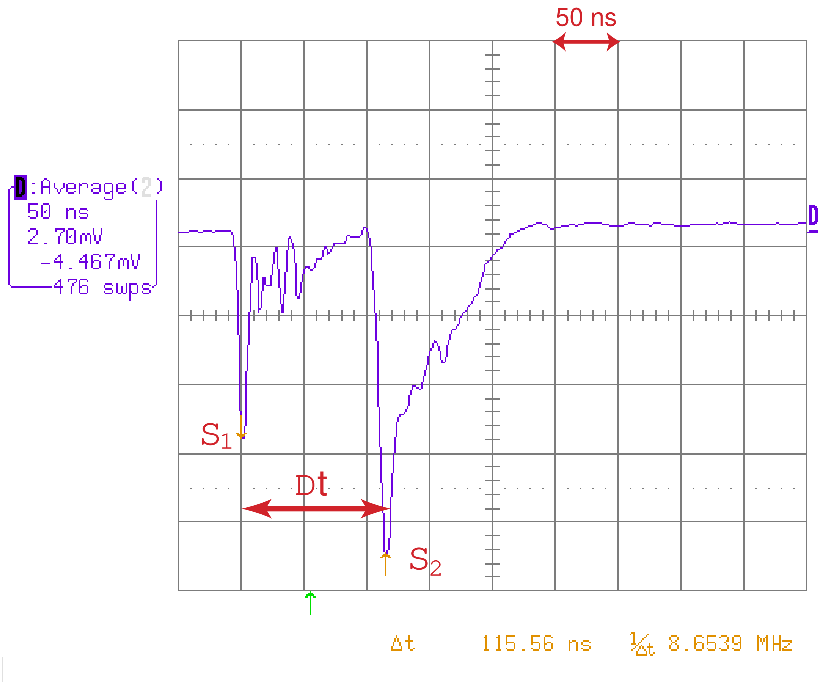

Fig. 2. Signal measurement.

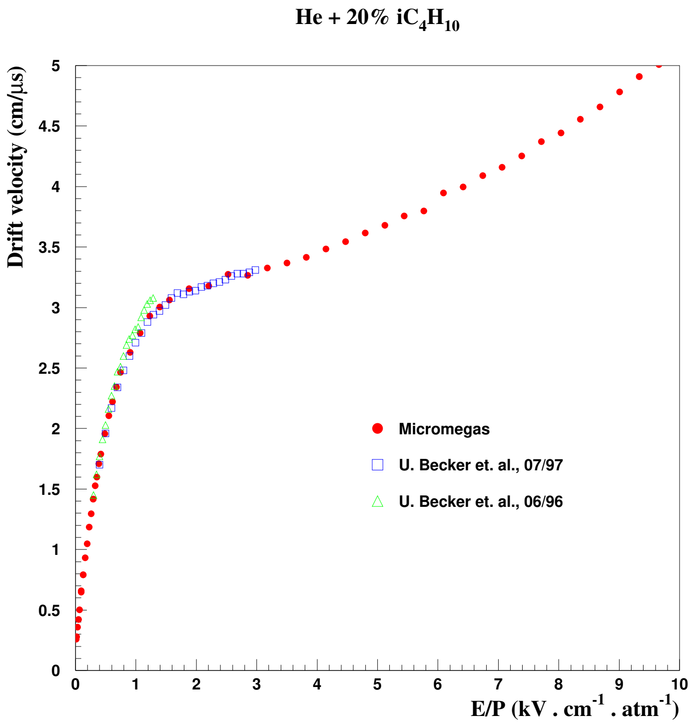

Fig. 3. Calibration in Helium mixture.

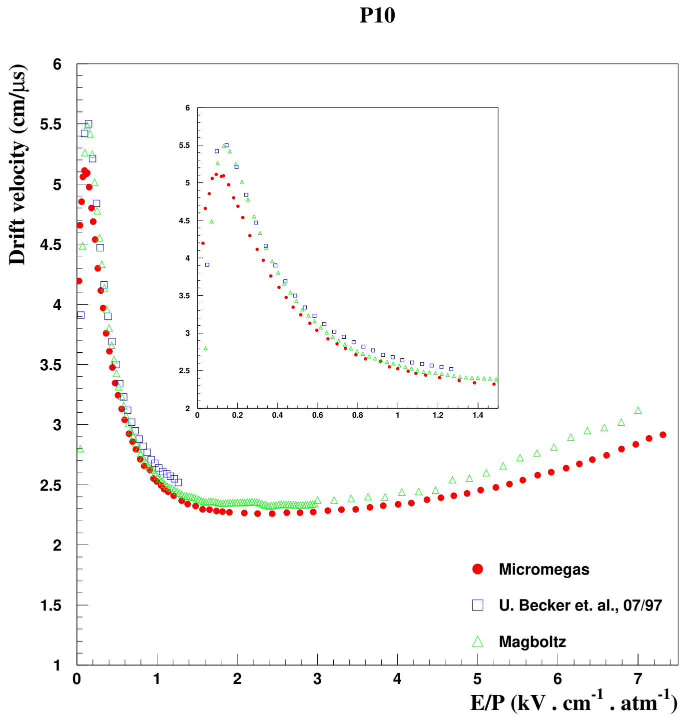

Fig. 4. Calibration in P10.

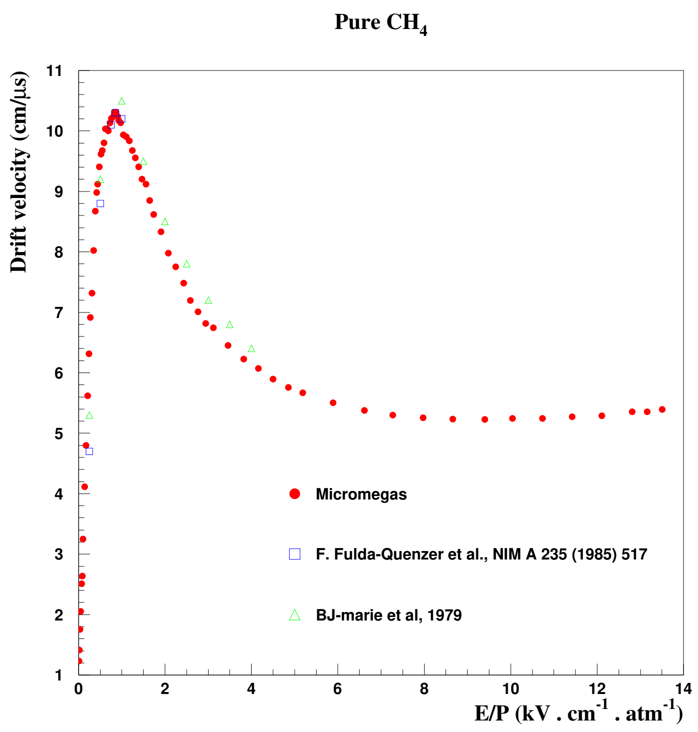

Fig. 5. Calibration in pure CH_4.

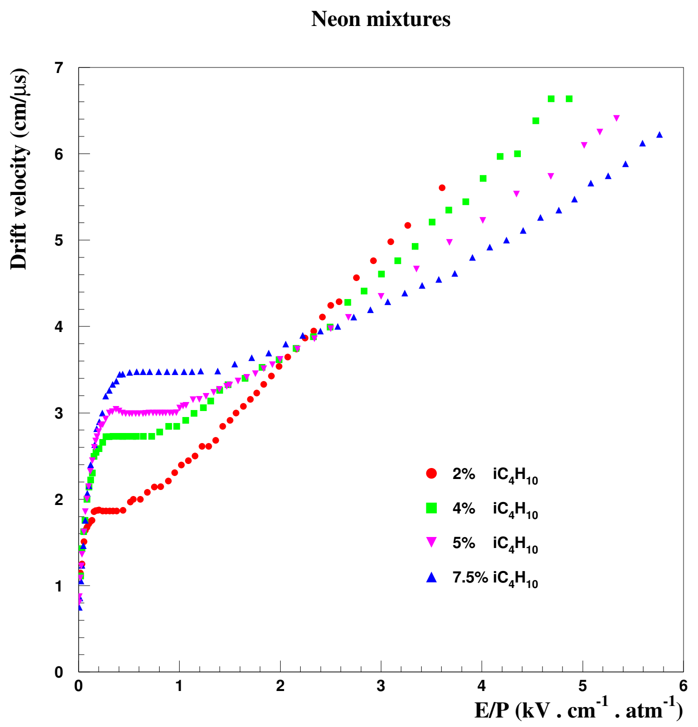

Fig. 6. Drift velocity in neon mixtures.

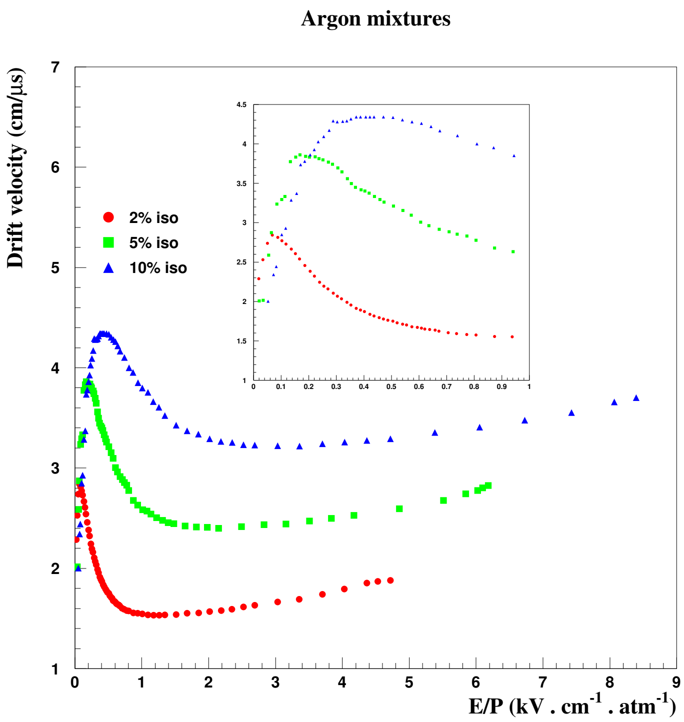

Fig. 7. Drift velocity in argon mixtures.

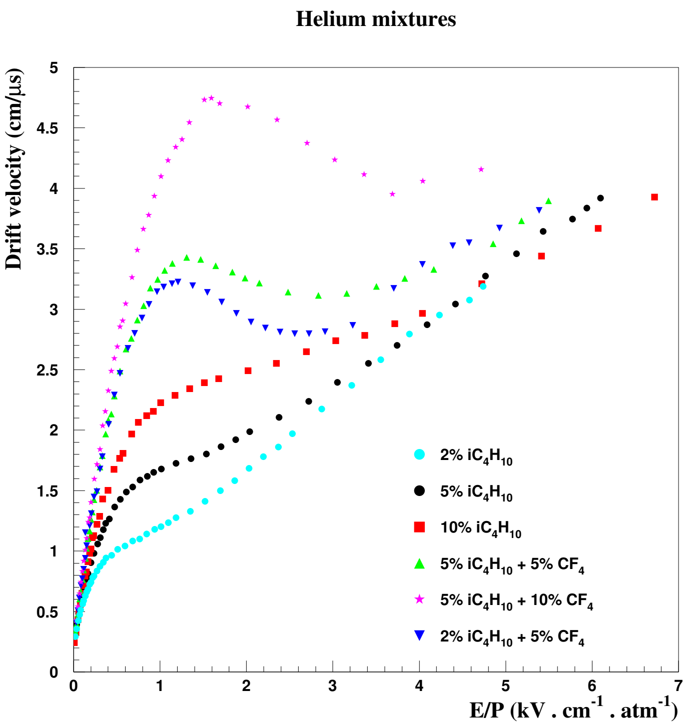

Fig. 8. Drift velocity in helium mixtures.

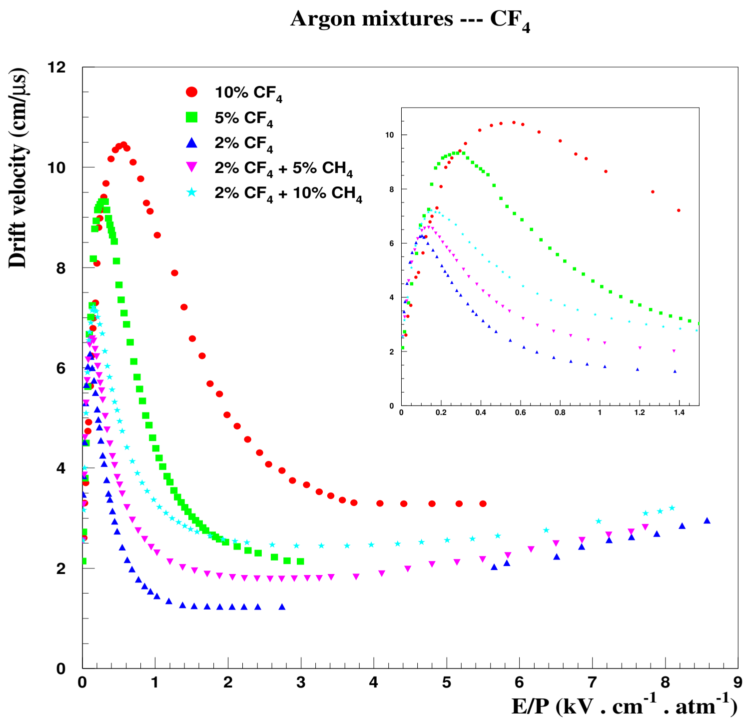

Fig. 9. Drift velocity in argon with CF_4 fractions.

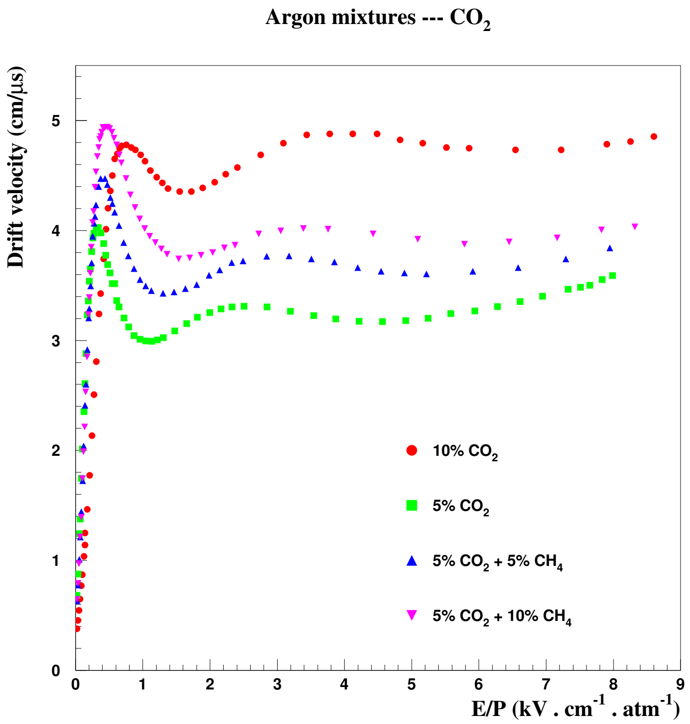

Fig. 10. Drift velocity in argon with $C0_2$ fractions.

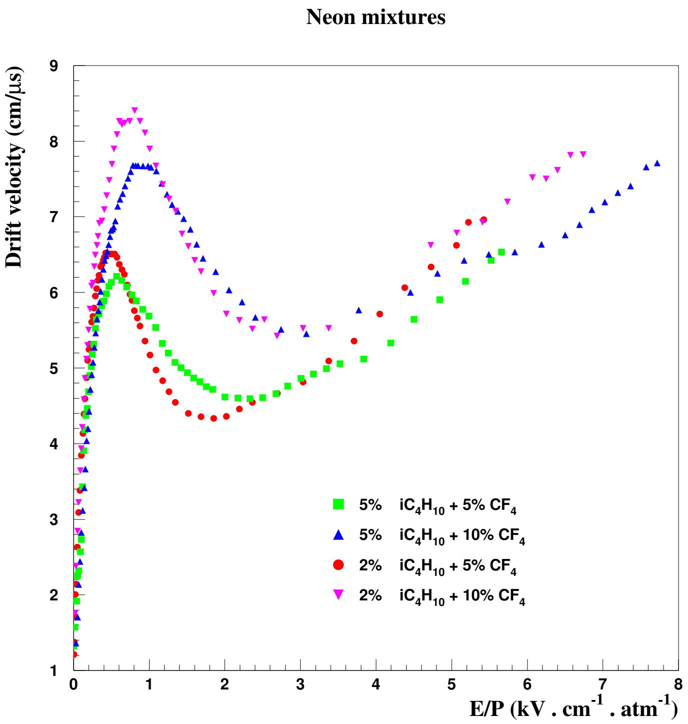

Fig. 11. Neon mixtures with isobutane and CF_4.

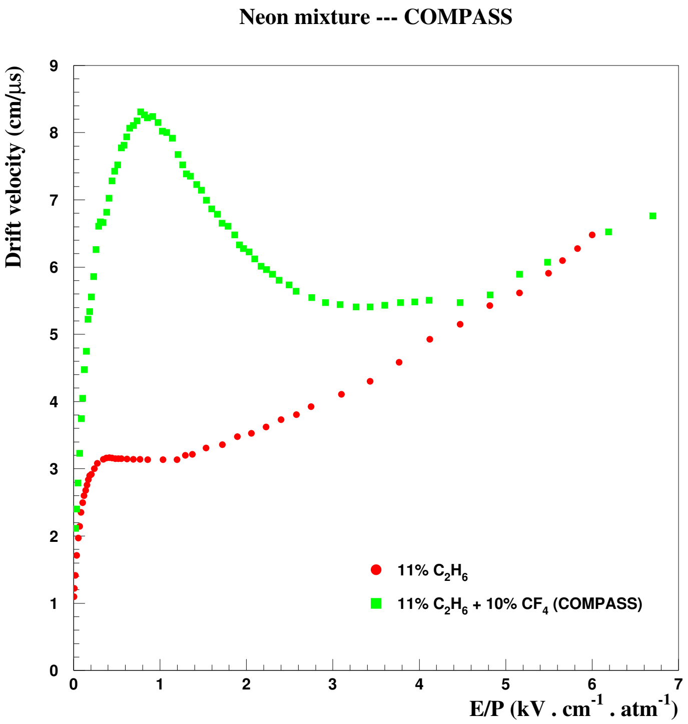

Fig. 12. COMPASS gas mixture.