CERN Summer Student Programme 2017 Report

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Abstract
This report describes the work done during my CERN Summer Student Programme 2017.

A set-up has been implemented to perform studies on possible aging effects caused by different materials and eventually to validate new components for future application at the LHC gas systems. The effects are studied with a Single Wire Proportional Chamber (SWPC), which is very sensitive to pollutants and gas mixture variations. In particular, we evaluate a new flow-meter (OMRON MEMS Mass Flow Sensor) and the effect of plastic pipe on detector gain and O_2 and H_2O variations. with Single Wire Proportional Chamber (SWPC). Chapter 1 describes the characterization of the SWPC. Chapter 2 focuses on the evaluation test of the flow-meter while Chapter shows the effects of the addition of a plastic pipe in the set-up.

Contents

Chapter 1

Performance test of SWPC

Single Wire Proportional Chamber (SWPC) is the simplest gas detector. Figure 1.1 shows its basic configuration. The detector is usually filled with a gas mixture containing Ar and CO_2. In presence of radiation, the gas is ionized and electron-ion pairs are created. When a voltage is applied to anode wire, electrons drift towards it by the electric field (which is inversely proportional to the distance from anode wire), and they are accelerated producing second ionization in the region close to the wire (avalanche multiplication). The signal collected from anode wire is proportional to primary ionization.

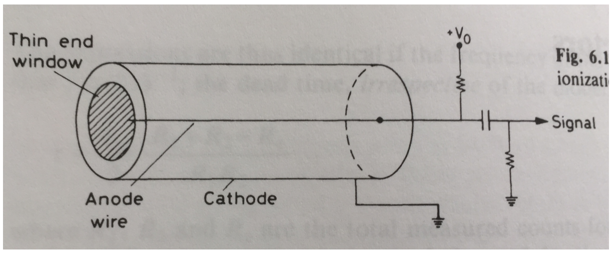
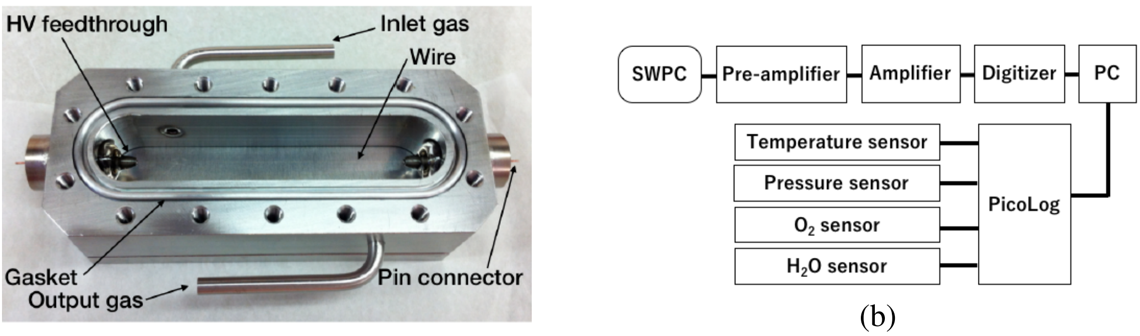


Fig. 1.1: Basic structure of SWPC [1].

1 Set-up

Figure 1.2 (a) shows a photograph of the SWPC used for the tests. An Ar/CO_2 (70/30) gas mixture is used for its operation. The SWPC is irradiated with a ^{55}Fe radioactive source having an activity of about 30 MBq. ^{55}Fe decays in ^{55}Mn emitting 5.9 keV photon. The source is cased in a metal case which has 3 holes to change the source intensity.



(a) (b)

Fig. 1.2: (a) Photograph of SWPC. (b) Schematic of data acquisition system

Figure 1.2 (b) shows the electrical schematics of the set-up. Output signal from SWPC is amplified by a pre-amplifier (CAEN A1422) and an amplifier (ORTEC 474 Timing Filter Amplifier), and then digitized using multichannel analyzer (CAEN Waveform Desktop Digitizer

DT57242). The pulse shape is recorded every hour in text format and binary format (for 60 sec each). The pulse height spectrum is analyzed with a C++ based software. Environmental parameters, such as temperature and pressure, are recorded by the ADC data logger (PicoLog ADC-24 [2]).

2 Characterization of SWPC

HV-scan and stability test are preformed to study SWPC performances and determine the operating conditions.

2.1 HV-scan with different thresholds

HV-scan is performed with different thresholds of the Digitizer to determine the operating voltage and threshold (Figure 1.3). In this test, ^{55}Fe source is located at the center of the SWPC and the smallest source intensity is selected. The HV working point chosen is 1900 V and 8500 adc counts as threshold.

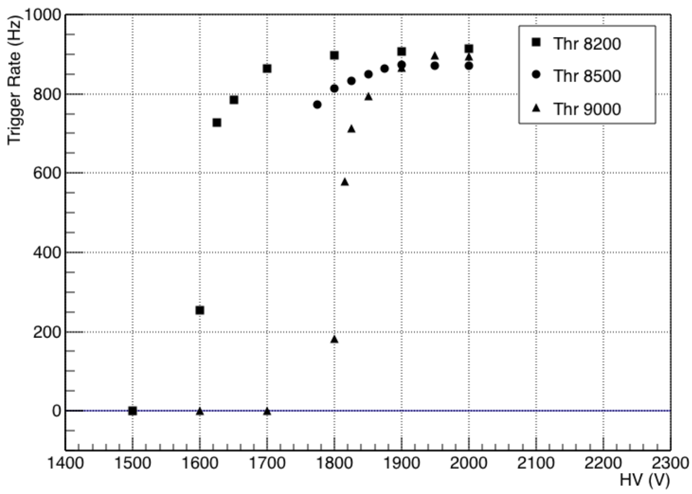


Fig. 1.3: HV-scan with different Digitizer thresholds.

2.2 HV-scan with different source intensities

Figure 1.4 shows the result of HV-scan with different source intensities. In this test, the threshold of the Digitizer is fixed at 8500 adc counts and source position is at the center of the SWPC. Trigger rate acquired from text file saturates at about 8 kHz while the trigger rate of binary file has no saturation until 33 kHz. This test shows that the Digitizer reording with a txt format does not allow to record trigger rates higher than 8 kHz. Since high trigger rate is not required in the following tests, the smallest source intensity is selected.

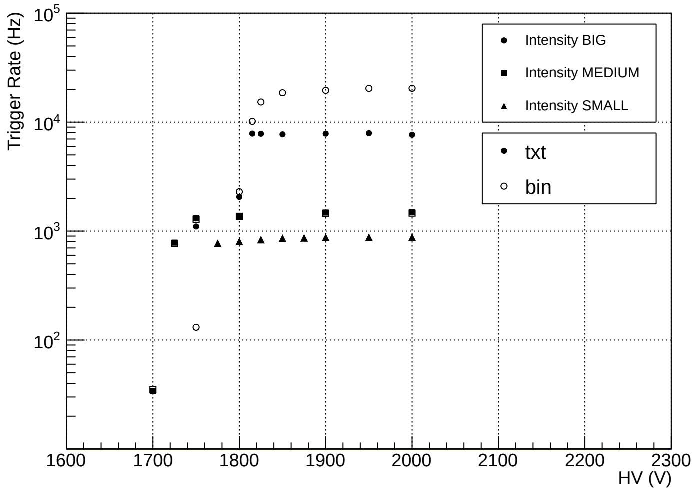
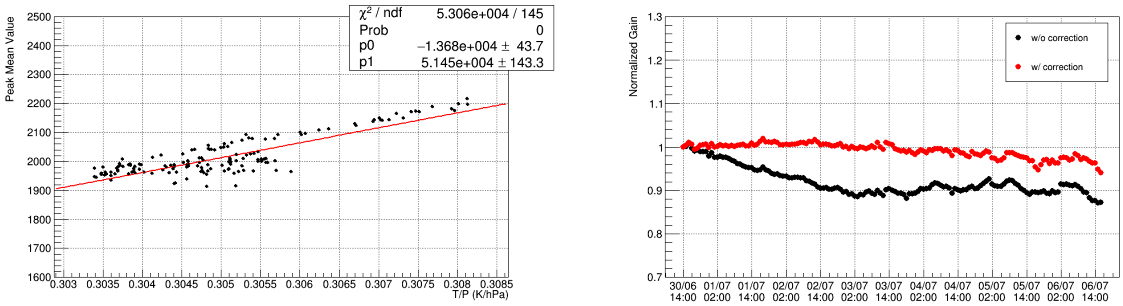


Fig. 1.4: HV-scan with different source intensity.

2.3 Dependence of SWPC gain for T and P variations

SWPC gain depends on temperature (T) and atmospheric pressure (P) variations and it is proportional to exp (T/P). Figure 1.5 (a) shows that the range of T/P is small enough to approximate exponential to linear function. Figure 1.5 (b) shows SWPC gain corrected by T/P is stable within $\pm 5\%$ for a week; therefore the SWPC is validated.



(a) (b)

Fig. 1.5: (a) SWPC gain as a function of T/P. (b) Trend of normalized gain with and without T/P correction.

Chapter 2

Performance test of Flow-meter

The goal of this test is to study the possible presence of outgassing for a flow-meter. The flow-meter has been connected at the gas input line of the SWPC. If the flowmeter produces outgassing, the SWPC gain is expected to decrease.

1 Set-up

The flow-meter used for our tests is OMRON MEMS Mass Flow Sensor D6F-P0001A1 [3]. Figure 2.1 (a) shows photographs of the flowmeter and Figure 2.1 (b) shows the response from its data sheet.

Fig. 2.1: (a)Photographs and (b) response of the flow-meter [3].

Figure 2.2 shows the set-up to test the stability of the flow-meter. The flow-meter is connected after a rotameter, which is set to 1.0 l/h. The output voltage of the flow-meter is read by PicoLog, then converted into flow by using the calibration formula (Figure 2.1 (b)).

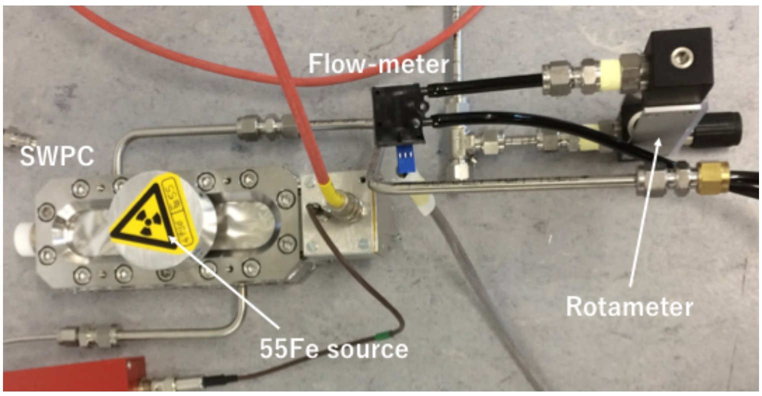


Fig. 2.2: Set-up for performance tests of Flowmeter.

2 Validation of flow-meter

Figure 2.3 shows the trend of the SWPC gain. The gain with T/P correction is stable within $\pm$ 3 %. This result indicates that there is no aging effect in the flow-meter and it is validated.

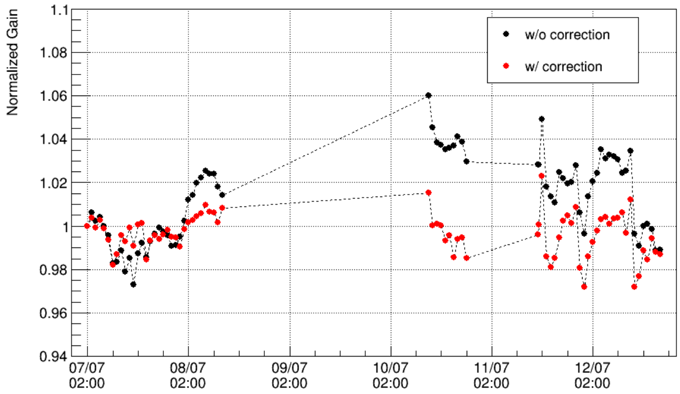
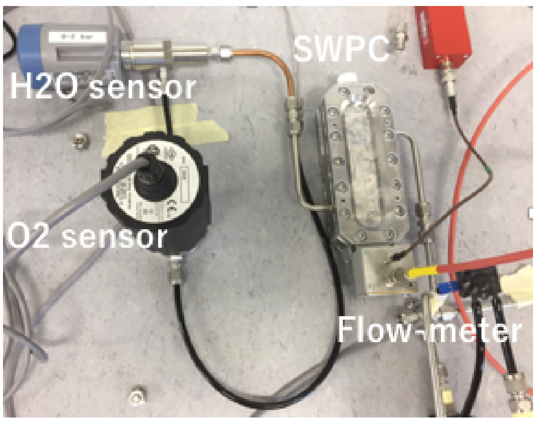


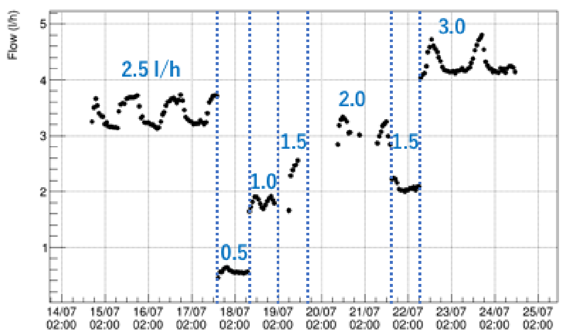
Fig. 2.3: Normalized gain trend with and without T/P correction.

3 Flow-scan

The purpose of this test is to study the dependence of the SWPC gain for different gas flows, O2 and H2O concentrations. O_2 sensor (GE Panametrics O2X1 Oxygen Transmitter [4]) and H_2O sensor (Vaisara Dewpoint Transmitter DMT242 [5]) are installed at the output of the SWPC (Figure 2.4 (a)). We changed the gas flow from 0.5 to 3.0 l/h (Figure 2.4(b)). The unit Vol/h is calculated by dividing flow by the volume inside SWPC (= 84 ml).



(a)



(b)

Fig. 2.4: (a) Set-up for flow-scan test. (b) Trend of the gas flow determined by flow-meter. Each number over the plots shows the gas flow set by the rotameter.

Figure 2.5 shows the dependence of SWPC gain for different gas flows, and the gain does not change with flow between 5 and 60 Vol/h. This is normal as the detector is flushed with a very high flow with respect to its volume and then it always works with clean and fresh gas.

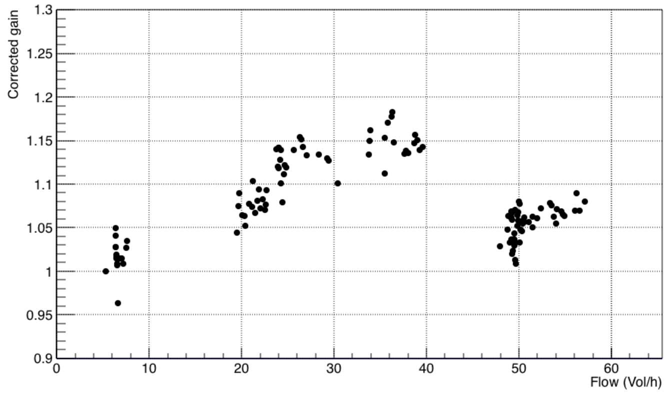
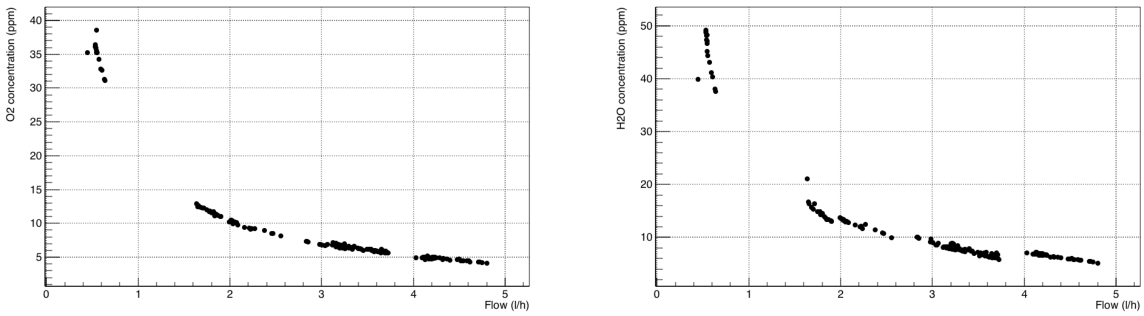


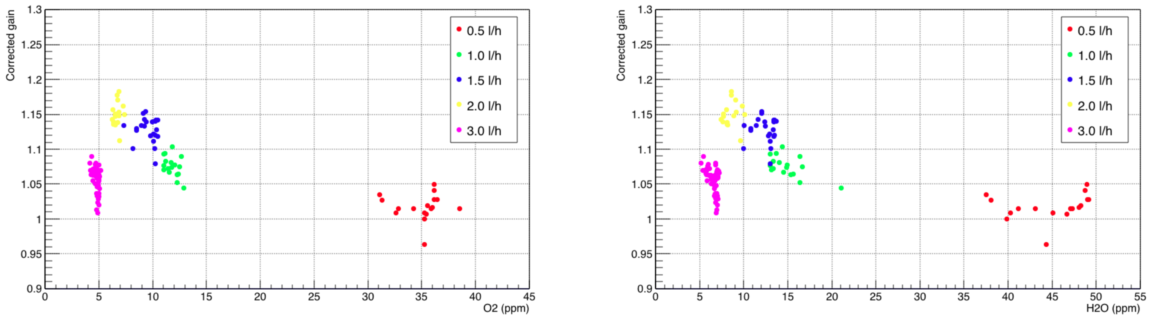
Fig. 2.5: SWPC gain corrected by T/P as a function of the gas flow.

Figure 2.6 shows that O_2 and H_2O concentrations change with the gas flow. The different gas concentrations can depend both from the gas flow and the sensor capability. As for O_2 sensor, its data-sheet [4] recommends 30 l/h for operation, and uniformity under 5 l/h is not mentioned. Figure 2.7 shows that the corrected gain does not change with O_2 and H_2O concentrations. This result also suggests that O_2 and H_2O concentrations determined by the sensors are not equal to the concentrations inside the SWPC.



(a) (b)

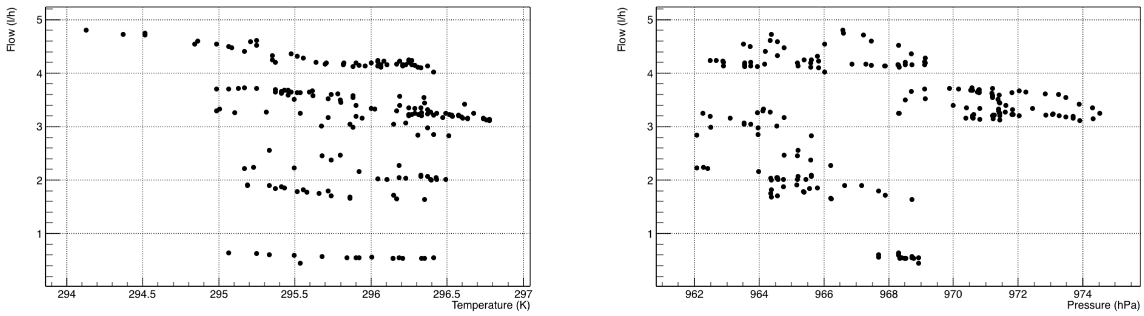
Fig. 2.6: (a) O_2 and (b) H_2O concentration as a function of the gas flow.



(a) (b)

Fig. 2.7: SWPC gain corrected by T/P as a function of (a) O_2 and (b) H_2O concentration.

Figure 2.8 shows the gas flow determined by flow-meter fluctuates with environmental parameters, and it depends more on temperature than pressure.



(a) (b)

Fig. 2.8: Flow as a function of (a) temperature and (b) atmospheric pressure.

Chapter 3

Performance test of plastic pipe

The aim of this test is to evaluate the amount of O_2 and H_2O transmitting through a plastic pipe.

1 Set-up

Figure 3.1 shows the set-up to test the plastic pipe. The diameter and thickness of the pipe are 6 mm and 1 mm respectively. The plastic pipe is located before the SWPC and different lengths have been tested. O_2 sensor and H_2O sensor are connected on the downstream side of SWPC.

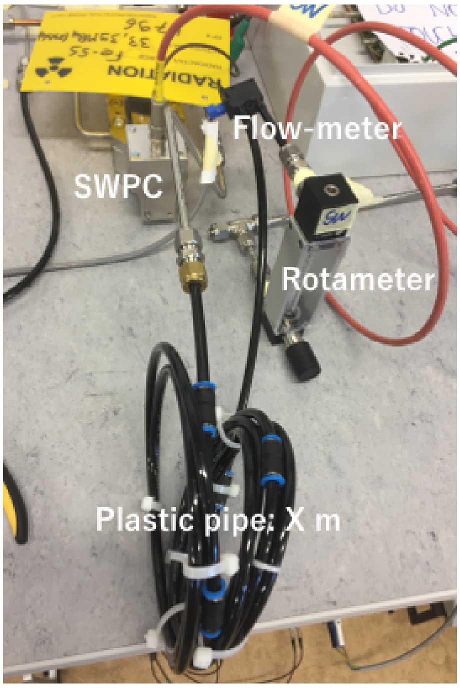
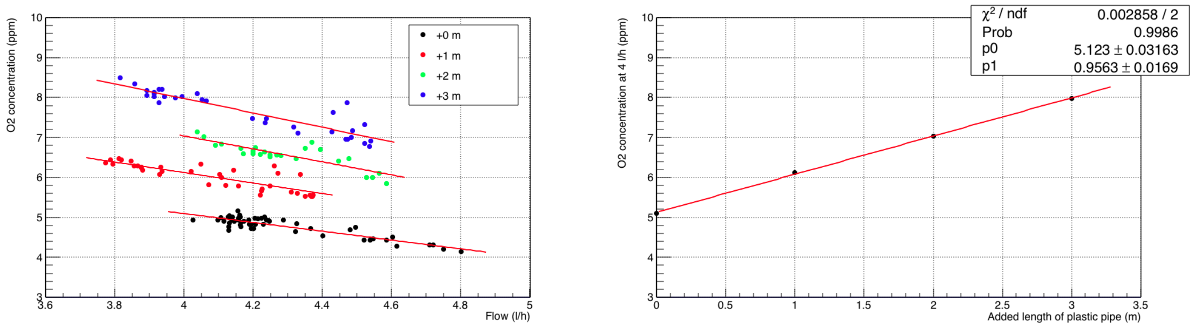


Fig. 3.1: Set-up for performance test of plastic pipe.

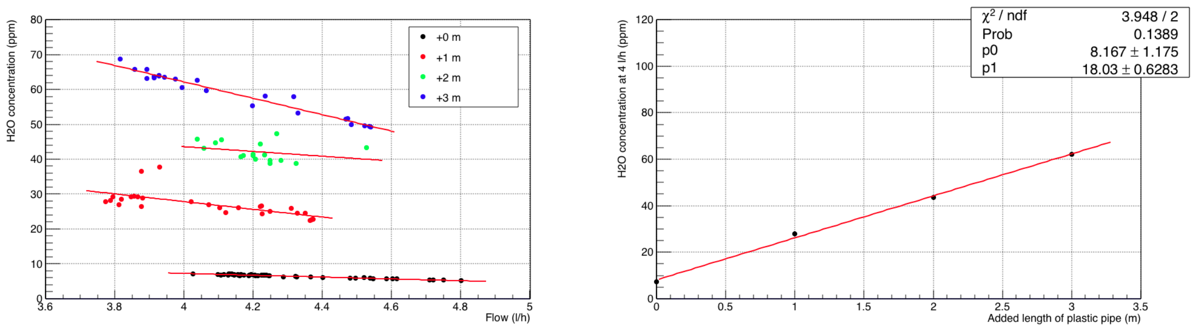
2 Length-scan

O_2 and H_2O concentrations are determined for different lengths of the plastic pipe and different gas flows. We add the pipe 1, 2, 3 m long while the rotameter is set to 3.0 l/h, and 3, 6, 9, 12 m at 5.0 l/h. Figure 3.2 (a) shows the correlation between O_2 concentration and the gas flow. In Figure 3.2 (b), O_2 concentrations at 4 l/h are calculated from these fitting parameters. The same method is applied for H_2O. Table 2 shows the summary of these tests.



(a) (b)

Fig. 3.2: O_2 concentration as a function of the gas flow and (b) the length of plastic pipe at 4 l/h.



(a) (b)

Fig. 3.3: H_2O concentration as a function of the gas flow and (b) the length of plastic pipe at 4 l/h.

Table 3.1: The amount of O_2 and H_2O absorbed by the plastic pipe.

	O_2 (ppm/m)	H_2O (ppm/m)
4.0 l/h	0.96 ± 0.02	18.0 ± 0.6
5.0 l/h	0.73 ± 0.02	14.0 ± 1.7

SWPC gain decreases if pollutants in the gas increase. In this test, O2 hardly contributes to the decrease in gain because its concentration (< 20 ppm) is too small [6]. Figure 3.4 shows the correlation between SWPC gain and H_2O concentration: there is a negative correlation and the gain decrease to 85 % at 140 ppm.

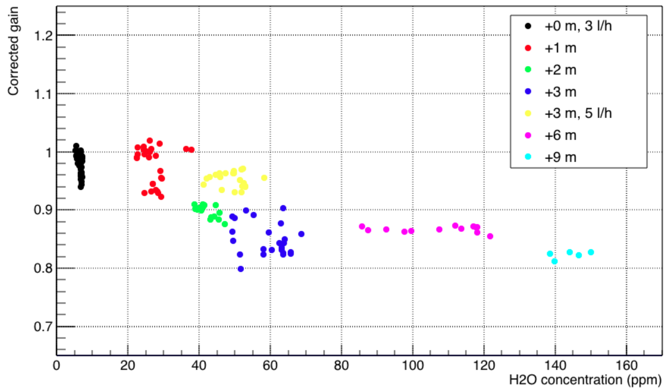


Fig. 3.4: SWPC gain corrected by T/P as a function of H_2O concentration

References

[1] W.R.Leo. Techniques for Nuclear and Particle Physics Experiments. 2nd Edition.
[2] https://www.picotech.com/data-logger/adc-20-adc-24/adc-20-and-adc-24-manuals
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