Knowledge of the gas gain is important to optimize the design, the constructive and the operating characteristics of TEPCs, especially when tissue sites sizes smaller than 1 µm are simulated. For simulating small site sizes, TEPCs of the order of cm must operate at very low gas pressures. In these conditions, phenomena governing the electron avalanche formation are not linear and the classical Townsend theory cannot be applied: effects related to the presence of an electric field gradient become important and must be taken into account.

**Objectives**

To measure the gas constants \( L, V, \) and \( m \) of the gas gain gradient-field model [1] in pure propane with a spherical TEPC.

\[
\ln G = \frac{L}{MV(1-m)} \left[ \exp(-MS^{-1}) - \exp(-MS^{m}) \right]
\]

\( L, V, \) and \( m \) are characteristics gas constants.

\( K = \frac{E(r)}{r} = \frac{\Delta V}{\ln(|r/r_0|)} \) detector with diameter equal to the spherical TEPC diameter.

\( K = \frac{E(r)}{r} = \frac{\Delta V}{\ln(|r/r_0|)} \) detector with diameter equal to the spherical TEPC diameter.

\( S, S_1, S_2 \) are the reduced electric field at the anode \( r_a \) and cathode \( r_c \).

Since the TEPC is not equipped with an internal \( \alpha \)-source, electron-edge \( y \)-values have been obtained from the proton-edge \( y \)-values, measured for each gas pressure, at the highest voltage, by using the scaling ratio \( W/W_0 = 0.969 \). Sharp proton edges have been generated by using 0.58 MeV neutrons of the \( ^{8}\text{Be}+\text{p},\text{n} \) reaction with 3 MeV protons.

**Materials and Methods**

**Experimental Gas Gain Measurements**

The absolute gas gain \( G_{exp} \) is obtained by using the electron edge \( y \)-value, of a \( ^{60}\text{Co} \) photon microdosimetric spectrum, as energy marker [3].

Measurement parameters:

- **Gas Pressure**: 5.5 mbar to 38.4 mbar (equivalent to sites of diameter \( d = 0.5 \) to 3.5 \( \mu \text{m} \))
- **Applied Voltage**: 620 V to 850 V
- **Anode Diameter**: 25 \( \mu \text{m} \) and 100 \( \mu \text{m} \)

\[ G_{exp} = \frac{(A \cdot H + B) \cdot C_{test} \cdot W \cdot f_{corr}}{y_{y,edge} \cdot f} \]

at channel of the pulse-height spectrum corresponding to the electron edge. \( A, B \) constants to convert from channel to voltage \( f_{corr} \) correction between pulse-height generated by a pulse and counter-pulse \( f_{corr} \) input test capacity of the preamplifier

\( y_{y,edge} \) mean chord length of the gas cavity

\( W \) mean photon energy to produce an ion pair

\( e \) electron charge

**Results**

The gas-gain model constants have been obtained best-fitting the 23 experimental data sets collected at different K-value.

\[ L | [\text{Td}^{1-m}] = 222 \quad V | [\text{V}] = 16.95 \quad m = 0.28 \]

The cylindrical gas gain model fits pretty well all the experimental data. The residual average value of all data is 2.8% and the residual dispersion (standard deviation) is 1.2%.

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Fig 1. Left: TEPC shielding housing. Right: TEPC with electronic board system.

Fig 2. Microdosimetric spectra in propane of neutrons of 0.58 MeV mean energy. Different lines correspond to site sizes ranging from 0.5 \( \mu \text{m} \) to 3.0 \( \mu \text{m} \).

Fig 3. Reduced gas gain against the reduced electric field at the anode. For sake of clarity, plotted data are a sub-set of three gas pressures, corresponding to 1 \( \mu \text{m} \), 1.5 \( \mu \text{m} \) and 2.5 \( \mu \text{m} \) site sizes measured with two different anode wire diameters.

Fig 4. Reduced gas gain against the reduced electric field at the anode. For sake of clarity, plotted data are a sub-set of three K-values. Measurements have been performed with two different anode wires. Note that the reduced gas gain depends also on the K-value, according to the gradient model.