Drift time and gas quality control in drift tubes by using secondary electron emission effect

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Abstract. An idea to use the effect of photon induced secondary electron emission to check drift tubes gas untightness and to control gas quality is investigated. The method is based on the measuring of time difference between the 1st and the 2nd pulses in a tube, when the following one is caused by photon induced secondary emission of electrons from tube wall. Some results are presented.

Introduction

Several short drift tube prototypes (Frascati, IHEP Protvino, Dubna, NIKHEF, Munich) were constructed and tested during 1995. All of them demonstrated more or less clear dependence r(t)-relation versus tube. There is an evident explanation of the phenomenon. The dependence of r(t)-relation from tube to tube is caused by gas mixture contamination due to untightness of end plugs and outgassing of them and gas pipes. A possible wire displacement can also contribute to the dependence. R(t)-relation is vitally important characteristic of drift tube. The relation is very sensitive to gas mixture contamination due to untightness of end plugs and outgassing of them and gas pipes. It is evident, that r(t) must be controlled regularly. The 1st approach to the control of the r(t) is a comparison of maximal drift time in each tube which can be extracted from time hit distribution, but it require large statistics.

There is more easy way to measure maximal drift time in circular drift tubes - to use well known effect of photon induced secondary electron emission. The probability of such process is very high for aluminium tubes. The source of the photons is a primary avalanche. Appearance of the secondary electrons is well seen as a peak in distribution of difference between the 2nd and the 1st time hits in a tube. Position of the peak gives the maximal drift time. Of course the method will give the maximal drift time at some higher voltage as compare to working one, but it is fast, it doesn't require hard analysis and it can be used for individual tubes with beam, cosmic or another type of irradiation.

As example, in fig.1 it is shown distribution of difference between the 2nd and the 1st time hit for 2 tubes of 4x8 IHEP Protvino prototype. The data were taken during beam test of the prototype at CERN with gas mixture Ar-CO_2-N_2-CF_4=95-2-2-1 at 3 bar pressure and high voltage 3350 V. Horizontal scale units are nanoseconds. The 1st peak is caused by the δ-rays and overloading of amplifier. Hatched peaks are caused by the photon induced secondary electrons. The width of the peak (FWHM) is about of 20 ns and the maximal drift time can be measured with precision about of 1 ns.

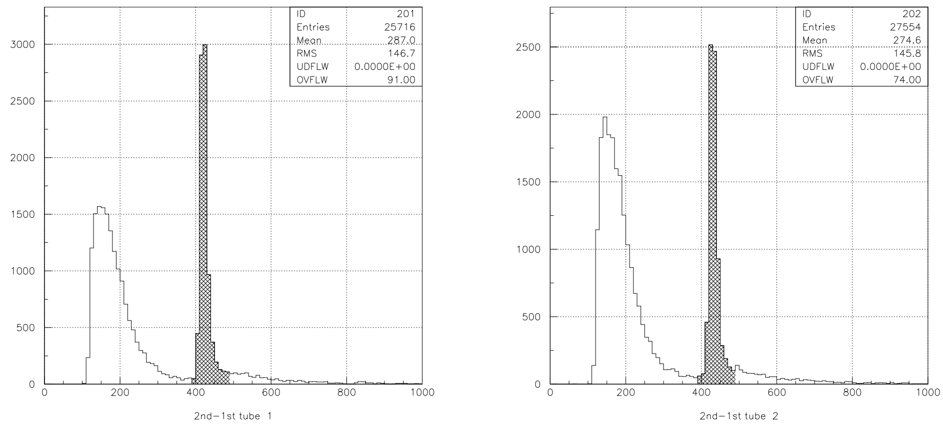

Fig.1 Distribution of difference between the 1st and the 2nd hits for tube 1 and 2.

Distributions shown in fig.1 correspond to 132 K events or about 12 hours data taking at M2 test area. The time of data collection can be reduced by several times without a loss of precision sion for maximal drift time. But very significant reduction of measurement time up to several minutes per one tube measurement can be reached with X-ray pulser. We performed such measurements at IHEP Protvino with our 4x8 prototype.

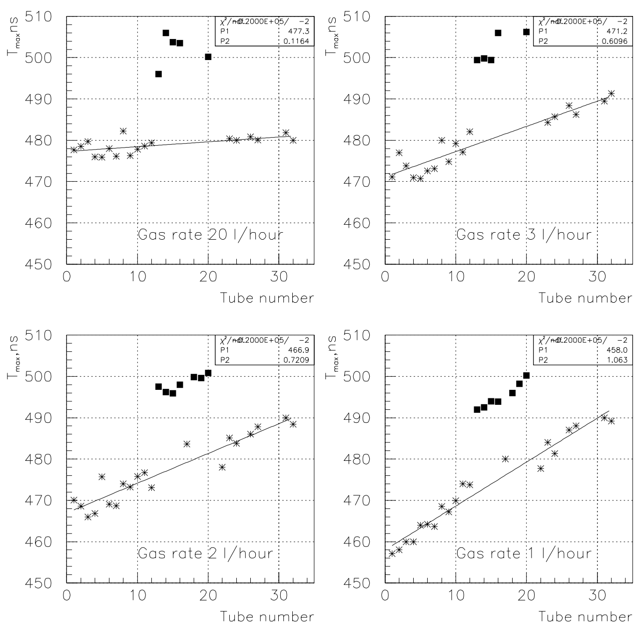

Fig.2 Maximal drift time versus tube number in series gas pipe connection for 4x8 prototype; gas Ar-CO_2=90-10, normal pressure.

Setup was the same as described in /1/. The measurements were done with Ar-CO_2-mixtures at normal pressure. Example of maximal drift time as a function of tube number in series gas connection is shown in fig.2 for 10% CO_2 at U=2.05 kV and four gas rate values: 1,2,3 and 20 l/hour. Points marked by squares correspond to tubes with larger (+0.5 mm) internal diameter. An increasing of maximal drift time versus tube number is seen. The slope of line fit is shown as P2.

We presented these results only to show the method of the maximal drift time measurement. Measurements with 4x8 prototype showed the disadvantage of series gas pipe connection and untightness of the prototype. Let us remember that tube end plugs were glued by epoxy compound.

For DATCHA 1 chamber which will be constructed at IHEP a new end plugs design with O-ring is considered. Several tubes with such design have been done and tested by described method. Below will be given some results.

Temporal and gas rate dependence of maximal drift time

Four tubes with end plugs made of plexiglass and sealed by rubber O-rings were connected paralelly. All gas pipes are made of copper or stainless steel. The length of drift tube is 20 cm. Total gas volume of four tubes is about 0.5 l. Measured leakage rate for 3 bars gas pressure was less than $6 \cdot 10^{-8}$ l·bar/sec for connected tubes.

We used gas mixture Ar-N_2-CH_4=94-4-5. At 3 bar pressure streamer discharge appears before significant secondary electron emission from wall. Due to overloading of amplifier by streamer pulse we could not measure maximal drift time by described method at 3 bar. Measurements were performed at normal pressure at constant V/p=2.93V/torr. Increasing of outgassing due to increasing of temperature was not taken into account. During daily measurements it was about 1-2^{o}C. Increasing of outgassing and change of the maximal drift time was seen due to such increasing of temperature during measurements.

We used the same amplifiers as at the beam test of 4x8 prototype. Drift time was measured by TDC with 10 ns bin width. Such bin is enough because of at normal pressure peak in T_2-T_1 distribution has width about 50 ns. It was fitted by gaussian which mean value was taken as maximal drift time. Number of X-ray pulses (5000) was chosen to obtain precision of maximal drift time about of 1 ns. It corresponds to duration of less than 2 minutes per 1 tube measurement.

In fig.3 temporal dependence of maximal drift time together with gas flow rate is shown. Measurements were started after several refresh of gas in tubes and switch on continues flow. Refresh means a filling of tubes by gas mixture up to 3 bar and opening output pipe to drop pressure to normal one. Measurements are grouped in some clusters which corresponds to one day measurements. Period between points in a cluster is about 1 hour.

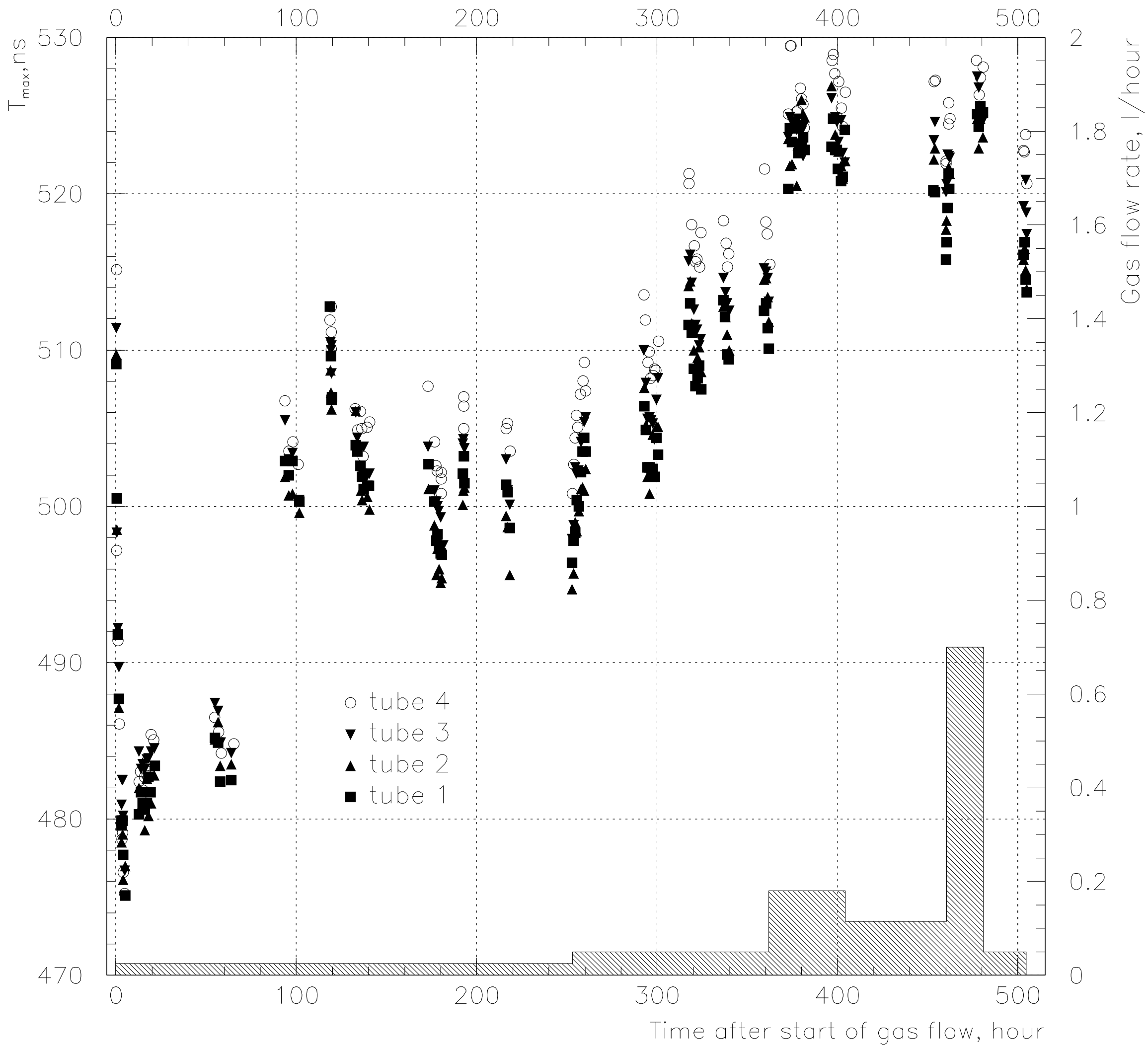

Fig.3 Temporal dependence of maximal drift time (left scale). Hatched area (right scale) is gas flow rate.

It is seen fast decreasing of maximal drift time due to outgassing of end plugs. Then there is slow rise with time. After 100 hours we reached some equilibrium for rate 0.025 l/hour. Several values of gas flow were tested. Several clusters of measured points are shown in fig.4 with expanded scale. Beginning of the horizontal scale at fig.4 corresponds to one at fig.3. Definition of markers is also the same as at fig.3. Decreasing of maximal drift time during a day measurement is seen in fig.4. It is about 1-5 ns/day. As it is seen at fig.3 decreasing of drift time is caused by increasing of some impurities. A probable explanation of daily decreasing of the time is increasing of temperature during a day period data taking and increasing of outgassing due to temperature increasing.

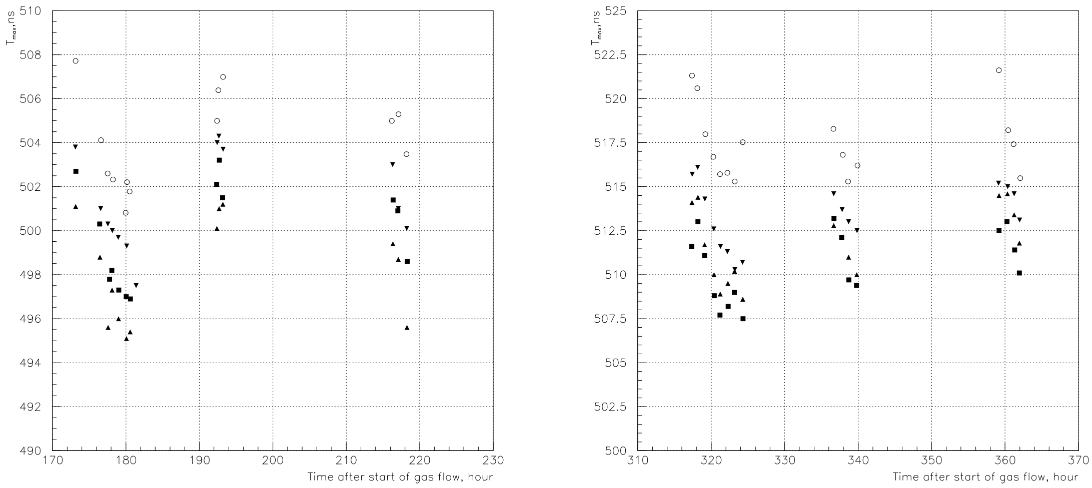

Fig.4 Temporal dependence of maximal drift time for several days

We also tested the equivalence of tubes concerning their maximal drift time. For each time of measurements we calculated mean maximal drift time for four tube and depicted difference between drift time of individual tube and the mean value (fig.5).

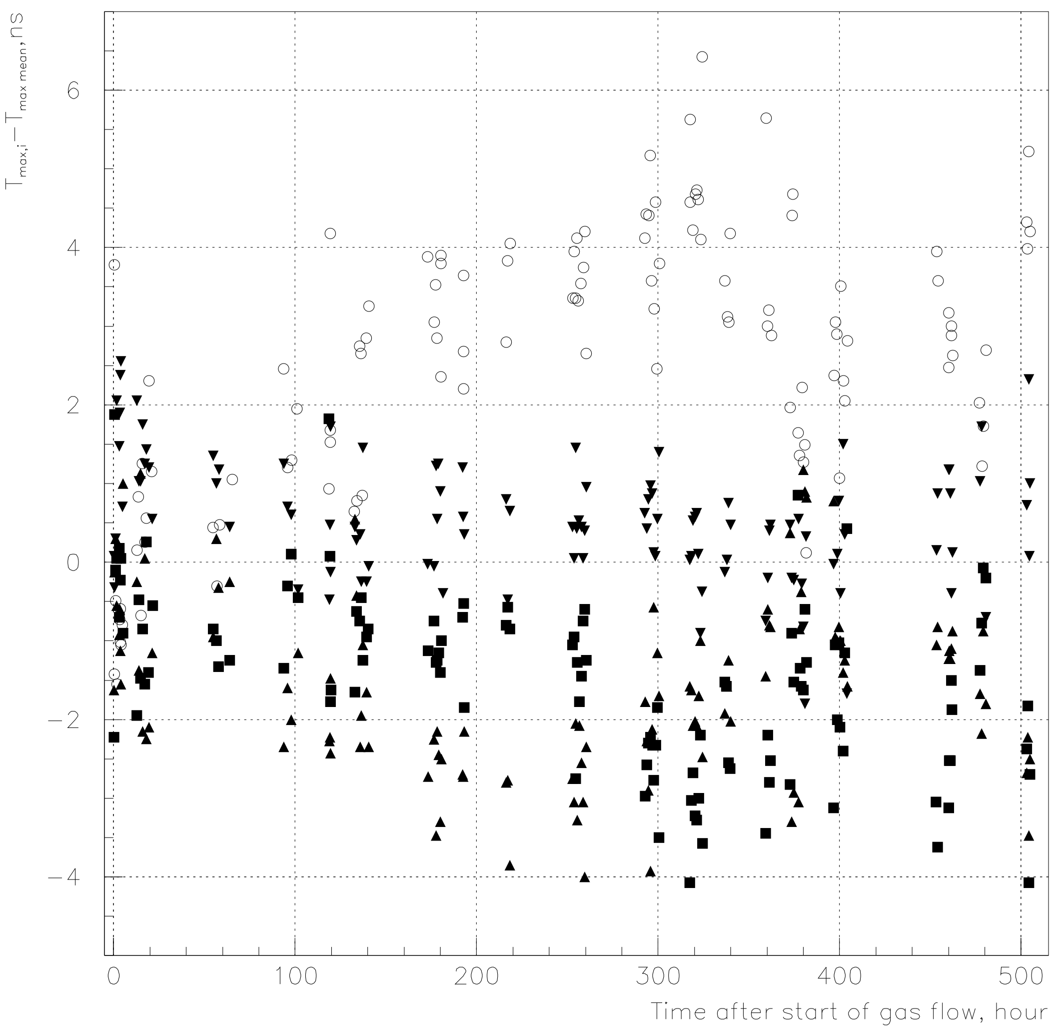

Fig.5 Temporal dependence of difference between maximal drift time in individual tube and mean value.

From the data shown in fig.3 we extracted dependence of maximal drift time versus gas flow rate (fig.6a) and difference of maximal drift time for individual tubes (fig.6b). The drift time was calculated as mean value for period of equilibrium between gas rate and outgassing process, e.g. for smallest rate equal to 0.025 l/hour we used interval from 90 to 280 hours (see fig.3), for gas rate 0.05 l/hour it was used interval from 320 to 360 hours and so on.

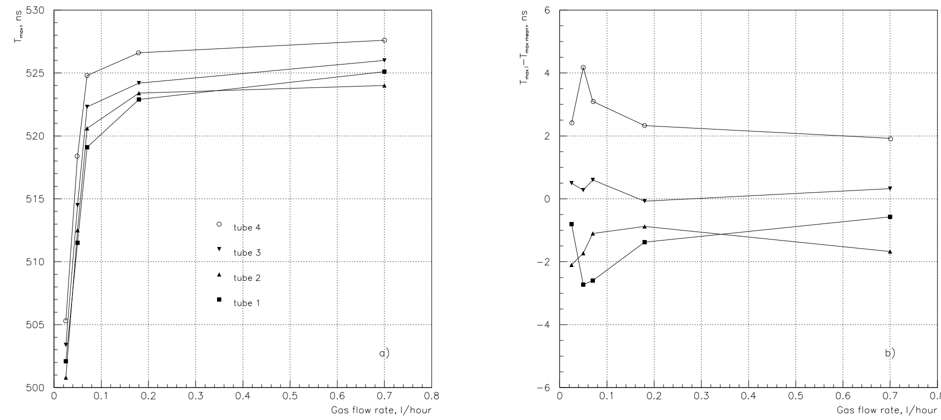

Fig.6 Dependence of maximal drift time (a) and individual tube difference (b) versus gas flow.

Conclusion

Using our "old" (autumn 1995) 4x8 prototype and 4 "new" drift tubes, we investigated possibility of maximal drift time control in an individual drift tube by using effect of the photon induced secondary electron emission. The procedure is fast and does not require complex analysis. Because of large sensitivity of the maximal drift time to gas contamination, such method is very useful for gas quality control and, consequently, for check of tube untightness also. It can be very useful for check drift tube quality during manufacturing. Using of the method in detector also possible with some restriction (gas composition and high voltage).

Long period test of four tubes showed that there is a systematic difference about 4 nanosecond for maximal drift time in individual tubes. We consider that possible explanation of the difference is tube geometry. My be, the described method can be useful also for control drift tube wall ellipticity and wire displacement. We shall try to check it.

References

1. X-ray tomography. Test of new setup and measurement of 4x8 drift tube prototype. A.Borisov et al. ATLAS Internal Note, Muon Note 109, 1 March 1996.