Gas Gain and Space Charge in Quick Aging Tests of Gaseous Detectors

T. Ferguson[1], A. Krivchitch[2], V. Maleev[2]

presented by **Victor Maleev**

1) Carnegie Mellon University, Pittsburgh, PA 15213, USA
2) Petersburg Nuclear Physics Institute (PNPI), 188350 Gatchina, Russia

We present the results of investigations into the gas gain of straw drift-tubes under different irradiation intensities from a ^{90}Sr beta-source. Tests were performed with a gas mixture containing Xe, CO_2 and CF_4. The goal of this investigation was to show how to optimize the choice of the high voltage for quick aging studies of modern gaseous detectors. In order to perform the aging investigation within a reasonable time period, the rate of accumulated charge should be at least 10 times more than what is expected in a real experiment. This forces us to choose a reasonably quick charge accumulation of about 0.1 – 0.2 C/cm per day (1 – 2.5 μA/cm). In order to be as close as possible to the real experimental conditions, the high voltage should be chosen so that it compensates the space charge that affects the gas gain in such quick aging tests. It was shown that performing aging tests without such compensation prevents any sufficiently reliable extrapolation of the obtained results to the real experimental conditions.

Summary of Poster: The main goal of this work was to investigate the influence of space charge on the gas gain for different irradiation rates. These investigations were performed with straw drift-tubes, designed for the ATLAS TRT, and operating with a $Xe/CO_2/CF_4$ 70:10:20 gas mixture. The straw tubes used in our investigations had a diameter of 4 mm. The cathode was made of 50 μm carbon-coated kapton film and the anode wire was made of gold-coated tungsten wire with a diameter of 35 μm. The gas gains have been measured for different irradiation intensities from a ^{90}Sr beta-source, which correspond to the ionization plateau of the current densities in the range of 2 – 60 pA/cm. It was shown that the limited streamer mode, which is an additional strong source of the space charge production, became quite noticeable starting from a gas gain of about $4.5 \cdot 10^4$ and quickly rose depending on the increase in the high voltage. It is possible to point out two options how to choose the applied high voltage to perform the quick aging test. The first one is to fix the gas gain under definite high voltage and to carry out the aging test under intense irradiation. In this case, the space charge decreases the gas gain and therefore reduces the electron component of the negative charge flow to the anode. The second one is to perform the aging investigations with increased high voltage to compensate the space charge influence on the gas gain in the irradiated zone. It was shown that even under a moderate rate of charge accumulation (1.5 μA/cm) the gas gain drops by about 40% due to the space charge effect. Such a strong space charge contribution to the gas avalanche development causes inadequate extrapolation of results obtained in quick aging tests to the real experiment conditions. In order to be as close as possible to the real experimental conditions the high voltage could be chosen to compensate the space charge under intense irradiation. This would put the non-irradiated part of a wire at a too high gas gain. As a result, the gas gain was about 50% higher than nominal gain ($2.5 \cdot 10^4$) at the edges of the irradiated zone. This should be taken into account in the analysis of the obtained data. As a result of our investigations we propose a method which achieves a proper balance between reasonable irradiation rate and minimizing the gas gain drop due to the space charge effect in quick aging tests.