Humidity Dependence of Dark Currents and Anode Etching

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The intense radiation environment in the HERA–B experiment, being comparable to that of LHC experiments, requires that the detector be very resistant to high radiation loads. The Outer Tracker of HERA–B consists of drift tubes folded from gold-coated polycarbonate foils (honeycomb) and is operated with a mixture $Ar/CF_4/CO_2$ 65:30:5. The choice of the mixture (no hydrocarbons) and the gold-coating of the foil was the result of research on how to avoid anode aging (gain loss) and cathode aging (Malter effect). However, other, relatively less known aging effects appeared: rising conductivity of the wire-supporting strips and wire corrosion. These two aging effects could be prevented by keeping water at a proper concentration. In an attempt to interpret the test results, plasma phenomena such as production of certain molecular species, concentration of long-lived HF produced via CF_4 dissociation in the avalanche were semi-quantitatively estimated. The results of the aging investigations will be presented in the talk.

Summary of Talk: Aging tests of the Outer Tracker honeycomb chambers with gold-coated polycarbonate cathode using the mixture $Ar/CF_4/CO_2$ 65:30:5 did not show significant gain loss or Malter effect up to 5 C/cm of accumulated charge. However, other effects showed up: high dark current and anode etching. Strong dark currents (>0.3 μA/cell) were observed in honeycomb chambers when the humidity of the gas was rather high (>1000 ppm). These dark currents are characteristic for the specific design of the chamber since they are caused by increased conductivity of the wire-supporting FR4 strips, which are indispensable components of the chamber construction. The dark currents increased at the beginning of the irradiation and saturated typically after 0.3 C/cm. The effect can be explained by the production of HF which reacts with water forming slightly conductive hydrofluoric acid. Another effect, anode etching, caused wire rupture when the counting gas $Ar/CF_4/CO_2$ was very dry (humidity below 100 ppm). Electron microscopy showed that wires swell (the diameters increase by several percent) and the gold-coating on the wires peels off. Each investigated broken wire ruptured approximately in the center of the irradiated zone of the corresponding cell. The X–ray spectroscopy of heavily etched wires did not reveal the presence of any other species except tungsten (and gold) on spots where the gold coating was removed by plasma etching. However, oxygen usually accompanied tungsten if it was deposited (for example, in form of whiskers) above the gold surface of the anode or the cathode. It is concluded that fluorine is responsible for anode etching since this effect was effectively suppressed by water. The anode etching correlated with another effect, "transient aging" (which is not related to damage of chambers, in fact). The latter effect is a non-permanent drop of the gain during high rate operation which recovers after a short relaxation time. The "transient aging" was also considerably reduced when water was added in concentrations of more than 200 ppm. The effect probably arises due to the avalanche production of F_2, a very electronegative gas.