Laboratory Aging Tests for the BaBar Drift Chamber

(title assigned)

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Noise and Malter breakdown have been studied at high rates in a small drift chamber. The test chamber has the same small-cell structure and gas (He/Isobutane 80:20) as the BaBar drift chamber, and uses a 100mCi ^{55}Fe source. Exposing it to a high radiation level at an elevated high voltage purposely damaged the test chamber. Breakdown was then seen at low source levels (≈ 0.5 nA/cm). Additives such as H_2O and alcohol were shown to suppress breakdown in a damaged chamber, but not cure it. The most interesting additive was oxygen. When $200-500$ ppm of O_2 was added, a damaged chamber could operate at high currents, and when the oxygen was removed, the chamber could still operate at higher currents (25 nA/cm). This shows for the first time that running with an O_2 additive at higher rates can cure a damaged chamber. This may be important for factory type chambers that operate at high rates for long periods of time.

Summary of Talk: The BaBar drift chamber uses small cells and a gas mixture of Helium/Isobutane 80:20. The chamber soon ran into current-draw problems at high rates, and water was added to alleviate the problem. A small test chamber was built with a similar hexagonal cell structure to measure the safety factor that water provides at higher chamber currents. BaBar currently operates at 0.3 nA/cm of anode wire. The test chamber has a single anode wire (20 μm gold-coated tungsten-rhenium) surrounded by six cathodes (120 μm gold-coated aluminum) spaced 1 cm apart, and six bias wires further out that are biased to provide a 20 kV/cm field on the cathodes and 239 kV/cm on the anode wire. A 100 mCi ^{55}Fe source and attenuation foils provided any desired chamber current up to 25 nA/cm on the anode wire. A picoampmeter and a multi-channel analyzer measured the chamber current and pulse spectrum respectively. The flow rate of the gas mixture was 125 cc/min, which gave one volume change every 24 minutes. The exhaust gas passed through a bubbler and was vented to the atmosphere. With only the He/Isobutane 80:20 gas, the chamber could operate up to approximately 1 nA/cm of chamber current. Beyond that, the chamber current suddenly jumps by more than an order of magnitude, and remains elevated even if the source is removed until the voltage is lowered. This is the Malter effect. Just prior to the current jump, the pulse spectrum shows an increase in the number of small pulses that grow with time. Several additives were found that allow operation beyond 5 nA/cm. These were methylal(4%), 2–propanol(1%), and H_2O(0.35%). All these additives showed immediate improvement. Of these, H_2O was best in that it had no visible increase in small pulses, and could operate up to 25 nA/cm of chamber current. Propanol does nearly as well, but showed a slight increase of small pulses at high currents, while methylal could only reach 5 nA/cm and showed the smallest pulses. Oxygen was found to be a most interesting additive: At 500 ppm of O_2, it was possible to slowly bring up the chamber current to 25 nA/cm. If brought on too quickly, the chamber would ignite in Malter mode, but after repeated attempts would become stable. But the most important result is that when the oxygen is removed, the chamber was still able to operate at 25 nA/cm. The oxygen had cured what was a damaged chamber. The chamber was cycled through a damage step (by raising high voltage with maximum source) and cure step several times to verify the result. Also, a lower amount of oxygen (200 ppm) was shown to cure the chamber as well, but the training time was longer (a day rather than two hours). The fact that the chamber could not operate immediately at high currents with oxygen but had to be slowly trained is indicative that the oxygen reacts with and removes ingredients on the wires over a period of time. It requires both oxygen and a high current to cure the chamber. The high ionic current passing through the high electric field near the wire surface heats up the local gas, which allows reaction of oxygen with the carbon-based deposits on the wire surface. The CO, CO_2, etc. combustion products are removed from the chamber by the flowing gas. This talk shows the pulse spectra, the growth of small pulses before Malter ignition, the chamber current history during a curing cycle, as well as an understanding of the small pulse spectrum from ^{55}Fe.