Anode Wire Swelling – a New Phenomenon for Anode Wire Aging at High Doses

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We present results from an aging investigations of straw drift tubes placed under sustained irradiation from a 2 Ci ^{90}Sr β-source. Aging tests were performed with two different gas mixtures $Xe/CO_2/CF_4$ 70:10:20 and $Ar/CO_2/C_2H_2F_4$ 40:40:20. A thorough study of the aging phenomenon of gold-coated tungsten wires with a diameter of 35 μm was done with accumulated charges of 3.6 C/cm and 1.6 C/cm. As a result of the aging process, the gold coating on the wires was damaged, and the wire diameter increased about 5.6%. Using Nuclear Reaction Analysis (NRA), in combination with an SEM/XEM analysis, we determined that a direct correlation between the amount of oxygen inside the gold coating and the anode wire diameter exists. This anode-swelling effect can be explained as a result of tungsten oxidation underneath the wire coating. This phenomenon of anode wire swelling by forces applied from within the anode wire is a new phenomenon in anode aging.

Summary of Talk: In this talk, we propose another possible mechanism for anode wire aging, which starts from dissociation reactions in the avalanches and finally causes the oxidation of the wire's tungsten under the gold coating. It should be noted that in the center of the irradiation zone the total amount of oxygen collected in the gold has increased more than 20 times in comparison to the non-irradiated wire. Moreover, the peak oxygen concentration increased up to 10 times, achieving a very high value of $1 \cdot 10^{22}$ at/cm^3. An analysis of this phenomenon, including data obtained earlier and the data presented in this report, leads us to propose a new mechanism for anode wire aging. We attempt to describe this phenomenon in general terms, but have no pretensions that this process is entirely understood. Our goal is to show the interconnection between the main factors causing both the anode-wire swelling and the development of aging. It has been found that atomic oxygen plays a very important role in this anode-wire aging process and greatly speeds up the aging of anode wires under a high irradiation dose. We believe that measurements performed using NRA of the oxygen concentration and the depth of its penetration into the gold coating after irradiation provide an excellent method to compare the aging resistance of different wires. The presence of both xenon and water vapor in the gas causes additional pathways for the creation of chemically active radicals. Xenon and xenon fluorides amplify the etching process and provide an easy path for the oxygen to reach the tungsten. Traces of water vapor may stimulate the process of wire swelling due to the creation of hydrofluoric acid in the gas discharge. We do not have direct evidences that tungsten oxide plays the main role in the wire swelling. This is our assumption and is based on two facts. Firstly, a large amount of oxygen has been observed directly on the tungsten surface of the wire. Secondly, neither carbon nor fluorine are observed in noticeable amounts in the XEM spectra. Consquently, oxygen appears to be the important element. Many compounds are created by etching the gold and from reactions with the tungsten in the wire. Some of them are in the solid phase and their densities are lower than that of tungsten or gold. Thus, the swelling phenomenon can take place in the wire material. How many and what types of compounds form in the tungsten are still unknown and more studies are needed.