Experiences with the Central Tracking Chambers of CDF

(title assigned)

presented by **Morris Binkley**

Fermi National Accelerator Lab (FNAL), Batavia, IL, USA

The experience of CDF with the aging of gaseous wire tracking chambers located in the central region of the detector is presented. The primary chamber is a large axial drift chamber that is roughly 3 meters long and 3 meters in diameter. This large detector includes the gas mixing and delivery system and the small monitoring chambers required for its operation. The primary gas is a mix of Argon/Ethane 50:50 with a small addition of alcohol. The first large axial chamber accumulated a dose of about 0.05 Coulombs/cm on the inner layers during 'Run I'. Aging in the large chamber is compared to results from small prototype chambers.

Summary of Talk: At the heart of CDF, a large magnetic detector built to study 2 TeV $\bar{p}p$ collisions at the Fermilab collider, is a cylindrical drift chamber coaxial with the beam. The chamber is roughly 3 meters long and 3 meters in diameter. The chamber is filled with a mix of Argon/Ethane 50:50 with a small addition of alcohol (roughly 1%), primarily to reduce the effects of aging. The initial chamber (CTC) accumulated a dose of about 0.05 Coulombs/cm on the inner layers during 'Run I' and experienced significant aging. The CTC has recently been replaced by a new chamber (COT) with smaller cell sizes to accommodate higher interaction rates. Both chambers have 40 micron gold-plated tungsten sense wires. For the CTC, the potential and cathode wires were 140 micron or larger stainless steel 304. For the COT, the potential wires (that alternate with the sense wires) are also 40 micron gold-plated tungsten, but the cathode wires have been replaced by a mylar sheet with 350 angstroms of vapor-deposited gold. The endplates and outer cylindrical cans are aluminum and the inner support cylinder is carbon fiber covered with aluminum foil. Prior to most of the accumulated luminosity in Run I, aging tests were done using a realistic prototype of the inner wires in the CTC using gas directly from the CDF gas tanks. No aging effects were found for for an accumulated dose equivalent to 0.4 Coulombs/cm (to an accuracy of $\pm4\%$). In the middle of Run I it was found from the data that there were aging effects in the CTC at a much lower accumulated dose. The gain decrease was linear with integrated luminosity and corresponded to about 1000%/Coulomb/cm. In June 1994, CDF started using ethane from a new supplier and at about the same time the luminosity increased dramatically. The new supply of ethane had significantly larger amounts of ethylene; apparently naturally occurring ethylene-free ethane was no longer available. Tests indicated that the increased ethylene should have no effect on aging. Attempts were made by the vendor to convert the ethylene to ethane, but the new gas typically did have a few thousand ppm ethylene and propylene. There was not enough data to reliably measure what the aging rate was before the change in ethane supply in June 1994. Some cleaning of the gas lines, valves, and alcohol bubbler and the addition of copper wool filters were done during 1995, but there was not enough data after these actions to tell if any of them had a significant effect on the aging of the CTC. Gas monitor chambers with ^{90}Sr sources to measure aging effects were introduced into the system in 1995. The charge accumulation in these chambers was large enough to get a measure of the effect of the various changes to the system. From these we know the following: April 1995: Measure aging directly after alcohol bubbler on the gas platform to be about 100k%/Coul/cm. Cleaning the system components (bubblers, valves, lines on gas platform) had no measurable effect. May – June 1995: Measure aging rate at input to the large CTC chamber (about 50 meters from the gas platform) to be (10k – 20k)%/Coul/cm. June 1995: Suspect aerosols from alcohol bubbler may contribute to accelerated aging. Add one copper wool filter after bubbler. Measure aging at the CTC input to be about (10 ± 1)k%/Coul/cm. Measure aging rate at the CTC exhaust to be <0.5k%/Coul/cm. July 1995: Using a new monitor chamber, measure aging after bubbler but before Cu wool to be still (100 ± 7)k%/Coul/cm. After Cu wool aging is (48 ± 7)k%/Coul/cm. August 1995: Add second Cu wool filter to canister and add a heater. Measure aging after Cu wool canister to be (16 ± 4)k%/Coul/cm. November 1995-February 1996: Add third and fourth Cu wool filters in a 2nd canister with heater. Increased alcohol temperature so that it was necessary to flow only 1/6 of the gas through the bubbler. Aging was measured after heated Cu wool filters to be (50 ± 30)%/Coul/cm. Aging at the input to the large CTC chamber was measured to be (12 ± 29)%/Coul/cm. The aging at the output of the large CTC chamber was measured to be (76 ± 21)%/Coul/cm. To help interpret the above results, sample wires were scanned using electron microscopes. Energy and Wave Dispersive Spectroscopy (EDS and WDS) gave a spatial resolution of a few nanometers and good automated elemental spectroscopy. Additional Fourier Transform Infrared Spectroscopy (FTIR) gave the capability of measuring molecular bonds. Before implementing the full Cu wool filtering and reducing the gas flow through the alcohol bubbler, the wires aged in test chambers on the gas platform and at the CTC input showed carbon-dominated deposits with aliphatic hydrocarbon chains. Pictures showed a smooth coating with occasional "nodules." Findings on an aged CTC wire were similar although the coating was thinner and the "nodules" more sparse. Wires from a bench test chamber using standard CDF gas with no alcohol had significantly different deposits that were rich in silicon and oxygen in the form of amorphous SiO_2. Pictures showed a landscape of thin fibers that resemble a burnt out, dense forest. The results for the CTC are consistent with aging due to a long-lived aerosol generated by a large flow rate through the alcohol bubbler. After the improvements, monitor chambers indicated that the aging rate due to the CDF gas system was less than 100%/Coul/cm. Subsequent bench tests on small COT prototype chambers measured an aging rate for Argon/Ethane with alcohol of less that 5%/Coulomb/cm. The CDF gas system has received more cleaning and new filters (mostly carbon). After the first few months of COT operation, monitor chambers after the Cu wool canister, at the COT input, and at the COT exhaust all measure aging rates less than 5%/Coul/cm.