The Radiation Environment and Damage in the CDF Tracking Volume

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Most experiments to measure the properties of fundamental elementary particles view the remanents of collisions between beams of high energy particles. The detectors used in such experiments are, necessarily, sensitive to radiation and may be damaged by both acute and chronic radiation doses. In fact, the useful lifetime of a detector is often determined by the total accumulated radiation dose absorbed by that detector. Knowledge of the spatial distribution, dose rate and sources of radiation are critical components in establishing which detector technology to use in the design of an experiment, estimating the detector lifetime and planning for detector replacement.

Until recently, expected detector lifetimes were based on prior experience with a similar detector under similar conditions, eg: [1, 2], or a combination of radiation damage measurements and computer simulations of the radiation environment eg: [3]. However, few measurements of the actual radiation environment exist in the literature. Our group has made the first detailed measurements of the radiation field inside the tracking volume of the collider detector at Fermilab (CDF) near the region of proton-antiproton collisions [4]. Our initial measurements used thermal luminescent dosimeters (TLDs) to establish the spatial distibution, dose rates and relative contributions from beam losses and collisions.

We present here updated measurements using new data from TLDs and additional instrumentation. With the larger dose accumulated by the CDF silicon vertex detector (SVX-II) immediatly surrounding the proton-antiproton collision region, the silicon sensors are now in a regime where their reverse bias current is dominated by bulk damage to the silicon. Radiation induced bulk damage to a silicon detector is directly proportional to the particle fluence through that sensor. We compare our radiation field measurents with the particle fluences calculated from the increase in reverse bias currents measured in the silicon and find good agreement. Finally, we have used standard simulation tools to estimate the radiation field from beam losses and collisions. We compare the results of the simulations with our data.

References

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