2.11 Radiological Issues at JLab - Lessons Learned from the PREX Program

Rakitha Beminiwattha [1]
Louisiana Tech University
Physics Department
U.S.A.

Abstract

In this talk the impact of high-intensity photon sources on radiological issues for experiment/equipment in the experimental hall is discussed, specifically for the PREX/CREX and MOLLER experiments at JLab.

1. **PREX-I** PREX-I experiment used a beam intercepting collimator to block low angle scattered electrons and Bremsstrahlung photons. The collimator aperture was set at 1.27^o but the main limiting aperture, the scattering angle above which beam interact with the beam pipe was smaller than the collimator aperture and it was located at the downstream area of the septum beam pipe (the gate-valve) at 0.84^o. The electromagnetic power from the low angle scattered electrons and photons from the lead target interact at the collimator as well as at the limiting aperture. They acted as secondary neutron sources. A combination of fringe field leak from the septum magnet into the beam-pipe and the limiting aperture at septum area resulted in significant spray in to the hall and beam-pipe downstream of the septum area. This produced many secondary radiation sources along the beam-pipe in the hall A during PREX-I experiment. Due these issues, PREX-I produced more neutron radiation compared to any standard hall A experiment.

2. **PREX-II** The main strategy for PREX-II experiment is to use a single collimator to stop everything that misses the dump and act as the limiting aperture for the experiment. The collimator aperture for PREX-II is set to 0.78^o. The new collimator will intercept about 2 kW of power at 70 μA from the beam and it is expected to produce more neutrons. The PREX-I collimator only intercepted 500 W. The collimator is designed to self-shield high energy neutrons and slow down to more softer neutron spectrum (less than 10 MeV) using an outer tungsten jacket. The inner cylinder of the collimator which directly interact with the beam is made out of copper-tungsten alloy to provide good thermal conductance for better cooling. This inner core will be water cooled. Then a neutron shield is implemented around the collimator to reduce the soft neutron energy spectrum. The soft neutron energy spectrum is shielded using high density polyethylene (HDPE) that provide full shielding around the collimator. Due to high intensity beam interactions the collimator will be heavily activated by the time PREX-II is completed. Therefore, the collimator will be retracted to a 5 cm thick lead shielded box before de-installation.

3. **Impact of neutrons** The main problem caused by neutron spectrum produced by PREX-I experiment was due to cumulative effects of displacement damages to Silicon in electronic

[1]Email: rakithab@latech.edu

devices. The atomic degradation overtime will ultimately proved destructive for electronics in the Hall A. Many power supplies and other electronics were damaged during the PREX-I experiments. One unique observation was that many optocoupler units were damaged more often than other electronics units. This was due to lower threshold for failure of optocoupler due to neutron cumulative effects. Therefore as a preventive measure all the optocoupler units were removed from the Hall A. Also PREX-II experiment will be designed to have about order of magnitude less neutrons produced compared to PREX-I experiment.

4. **Conclusion** In concluding, a combination of large aperture collimator and septum fringe created many neutrons sources in the hall during PREX-I. Isolating the main neutron source and then shielding adequately this main source is the optimum solution to minimizing the neutron radiation. This include use of self-shielding collimators and them use concrete and HDPE to shield neutrons. The studies have shown that collimation and shielding strategy reduces the expected radiation load in PREX-II to the level of previous successful experiments such as HAPPEX-2 or PVDIS in the most sensitive region of the hall. The simulation benchmark between Geant3, Geant4, FLUKA, and MCNPX have shown that agreement of neutron production is withing a factor of 2. Comparison of simulation results with RADCON data during PREX-I experiment have shown that there is a factor of 2 safety margin between simulation and measurements.