Radiation and Activation with SoLID

Radiation and Activation with SoLID has been studied using the two simulation packages with independent code base (Geant4 and FLUKA). This allows independent cross checks both in geometry and in physics modelling. At the same time the two codes each provide unique capabilities expanding the overall reach.
A shielding configuration has been implemented when needed in the current detector design in order to reach operational radiation levels during beamtime.
An estimate of the prompt radiation and activation in the detector and in the Hall has been calculated in order to determine and mitigate the inpacti in the SoLID detector and in the Hall (both at beamtime and downtime).

Advantages and Disadvantages of each Simulation Code

FLUKA is specifically suitable for radiation background calculations and essentially is the only code capable of doing material activation calculations.
The disadvantage is however the absence of the direct electronuclear dissociation and fragmentation models in the list of Physics processes implemented. Such electronuclear reactions are dominant in the neutron production from the Liquid Deuterium target at high energies.
In order to overcome this problem FLUKA has been implemented with a source term for lower radiation length materials like the targets. After different tests with different simulation software (GEANT3/DINREG, GEANT4, FLUKA) and comparisons with available experimental data, the choice for a common source term is fallen into GEANT4 (version 4.9.6p02) with Physics List QGSP_BERT_HP.

GEANT4 is the established framework for other part of the SoLID simulation project and is better for particular tasks in order to simplify the Shielding design (like vertex reconstruction and energy reconstruction on particle fluxes over regions of interest).

Radiation and Dose limits

PROMPT RADIATION LIMITS: In order to establish the effects and limits of the radiation damage on electronics, I used, in parallel to the calculation of full Dose estimates, the Displacement damage in silicon, on-line compilation curves by . Vasilescu (INPE Bucharest) and G. Lindstroem (University of Hamburg).
This curves assume that the damage effects by energetic particles in the bulk of any material can be described as being proportional to the so called Non Ionising Energy Loss and normalise the damage in Silicon to the one caused by a 1 MeV neutron.
Literature on radiation damage establish tolerance level for different materials and electronic parts as a function of fluence levels of radiation expressed in 1MeVneutron/$cm^{2.}$

DOSE (ACTIVATION) LIMITS: Thomas Jefferson Laboratary practices ALARA (As Low As Reasonably Achievable) and has an ALARA goal of 250 mrem per year to a rad worker (with a limit of 1 rem per year). With this in mind different simulation have been run with the different SoLID

configurations in order to establish high radiation areas for different time scales from irradiation. This has been done in order to take into account the different possible exposure that a rad workers will undertake at different time of the experiment: Run time, possible repair time and change of configuration.

Project Status

- Different Setups for SoLID (PVDIS, SIDIS) have been implemented in both software's codes with different checks for the consistency between the results. Other proposals using the SoLID detector still need to be directly addressed.
- For the configuration analyzed the radiation level at run time seems well in the limits of the tolerance level for the electronics used with SoLID. This radiation level was also a driving part during the design of the detectors.
- Other possible areas of discreancies between FLUKA and GEANT4 are known and will need to be addressed and quantified.
- .Different activation areas have been established with expected dose equivalent radiation at different times from beam exposure: Final tuning and possible shielding still need to be implemented in order to better follow the ALARA policy.