FLUKA Beginners' Online Training

Answers to the questionnaire on Scoring II

Question 1

The units of the particle fluence scored with `USRTRACK` card are:

A. $\mathtt{cm}^{-1}$, if the volume of the region is set in the card.

B. `cm`, if the area of the region surface is set in the card.

C. $\mathtt{cm}^{2}$, if the normalization field is empty.

D. **$\mathtt{cm}^{-2}$, if the volume of the region is set in the card.**

The particle fluence in a region is defined as the track-length of the particle radiation field divided by the volume of the region. Therefore, the unit of the fluence are $\mathtt{cm}^{-2}$.

Since FLUKA does not calculate the volume of a region, the unit of the results are $\mathtt{cm}^{-2}$ only if the volume of the region is set in the respective field of `USRTRACK` card. In case the volume normalization field is left empty, the result is track-length expressed in `cm`.

It is recommended to leave the normalization field empty and divide by the region volume in the post-simulation analysis.

Question 2

Select the false sentence in case the neutron fluence is scored down to thermal energies with `USRBDX` in 3 angular bins:

A. Below 20 MeV the binning boundaries are fixed by the low-energy neutron group structure.

B. **The order of the regions defining the boundary is not relevant.**

C. The result should be plotted as `"Lethargy plot"` to preserve the correct importance to the different energy bins in the plot.

D. The results are given in units of $\mathtt{GeV}^{-1}\mathtt{sr}^{-1}$ if the area of the detector is not set.

The fluence is weighted by the factor $1/cos(\theta)$, where θ is the angle between the particle direction and the normal to the boundary at the point of crossing. The normal direction is from the first region to the second region defining the boundary.

Question 3

The signal of an instrument is not proportional to

A. the fluence Φ of the radiation field in the detector sensor

B. the inverse of the free mean path λ

C. **the current J crossing the surface of the detector sensor**

D. the volume V of the detector sensor.

The response of a detector is proportional to number of reactions R, which is given by $R = \Sigma \times \Phi \times V$, where $\Sigma = \frac{1}{\lambda}$ is the macroscopic cross section, Φ is the fluence of the radiation field, and V is the volume of the detector sensor.

The response of a detector sensor is not proportional to the current J that is a quantity depending on the surface orientation.

Question 4

Which quantities should we score if we are interested in retrieving the SEE rate in a high-energy accelerator radiation environment?

A. Silicon 1-MeV and thermal neutron equivalent fluences.

B. **High-Energy Hadron and thermal neutron equivalent fluences.**

C. High-Energy Hadron fluence and Total Ionizing Dose.

D. Total Ionizing Dose and Non-Ionizing Energy Loss.

Silicon 1-MeV neutron equivalent fluence, Total Ionizing Dose and Non-Ionizing Energy Loss are used to estimated *cumulative* radiation damage.

In space, Single Event Effects are primarily induced by Galactic Cosmic Ray (GCR) heavy ions that have a large enough LET to upset electronics through direct ionization. In the high-energy accelerator environment, SEEs are triggered via indirect ionization events, generated by nuclear interactions from the environment constituents in the vicinity of the device's sensitive volume. Such events are mainly triggered through neutron capture (proportional to the thermal neutron fluence) and inelastic reactions induced by high-energy hadrons.

Question 5

In FLUKA, the High Energy Hadron equivalent fluence is defined as:

A. The accumulated fluence of all hadrons above 20 MeV.

B. The hadron flux weighted with the tungsten fission cross section.

C. **The accumulated fluence of all hadrons above 20 MeV, plus a weighted contribution of neutrons in the 0.2-20 MeV range.**

D. The integral of all hadrons above 20 MeV, plus a weighted contribution of lower energy neutrons according to their capture cross section.

The equivalent high-energy hadron fluence is, in first approximation, proportional to the Single Event Effect rate in microelectronic components. It is composed by all hadrons above 20 MeV, plus a weighted contribution of neutrons in the 0.2-20 MeV range which, due to their neutral character, can still generate nuclear reactions in silicon and other materials present in electronic components, hence leading to large enough energy deposition events to induce SEEs.