Background Radiation Studies at LHCb using Geant4

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Introduction

- LHCb is one of the experiments located in one of the collision points of LHC, the future 14 TeV proton-proton collider at CERN.

- The experiment is dedicated to the precise measurement of CP violation and other rare phenomena in the b system (W. Witzeling, “Status of the LHCb experiment”).

- Estimating the background radiation level in an experiment is necessary to understand how the radiation field generated by the collision of the primary protons can affect the detector and its electronics.
Possible damages can be:

- **gradual effects** (whole lifetime of the device), connected to the total ionizing dose (TID), displacement damage of silicon lattice by Non Ionising Energy Loss, etc.
- **local and acute effects** (energy deposited by a single particle), connected to the high energy charged hadrons (>20 MeV) interactions with the device ➔ Single Event Upset

Previous studies performed with FLUKA, GCALOR and MARS simulation packages

Feasibility of the same study with GEANT4. This toolkit is used by GAUSS, the LHCb simulation application for the Monte Carlo simulation of the particles interaction with the detector matter.
**Tallying dose and fluence in LHCb, using GEANT4**

- Main monitoring parameters in Background Radiation Studies are *fluence* and *dose*, delivered by the secondary particles.

- A module, called *Sensplane*, in GAUSS takes care of:
  - creating fake detector planes in user-defined positions (using xml), but not conflicting with previous structures.
  - sub-dividing the planes in several smaller cubes, with a user-defined size.
  - calculating the *fluence* and *dose* associated to the particle types relevant for the studies (protons, neutrons, charged hadrons, electrons and positrons, gammas).
  - Results are recorded as *2D maps* (on the detector planes) and as *energy differential spectra*.
  - Some distributions are combined in a post-processing stage (i.e. dose).
Geant4 production cuts: 5 mm for electrons/positrons and 10 mm for gammas.

Geant4 physics lists are used to combine several physics models: QGSP, LHEP, QGSP_HP, LHEP_HP (extension for neutrons energy lower than 1 keV), http://www.geant4.com/hadronics/GHAD/HomePage/

Primary particle statistics corresponds to 5000 pp collisions produced with Pythia 6.205
Preliminary results

Scoring plane at 2280 mm

Total ionising dose (Gy/collisions)  High energy hadrons fluence (1/collisions*cm²)
Scoring plane at 7830 mm

Dipole magnet spreads out Total Ionising Dose in the Y axis.
The total charged hadrons fluence shows symmetry around the beam centre-line. This is evident as in the high as in the low density fluence regions.
Neutron fluence grows moving towards the muon stations.

A detailed comparison of QGSP and LHEP does not show any relevant differences within the statistical accuracy. The same outcome for the comparison between QGSP.Highlighted and LHEP.Highlighted.

Future planning involves the analysis of the slight differences, recorded only in some energy bins, using a higher statistical accuracy.
Conclusions

- **GEANT4** has been used to perform Background Radiation Studies in LHCb

- Tallies of dose and fluence have been implemented using GAUSS and the *configuration of job via options*

  The scoring planes cannot overlap the LHCb geometry. Work is in progress to implement a parallel geometry

- **Four detector planes** have been used to demonstrate the feasibility of the radiation studies using Geant4 and to compare relevant physics lists. The results show a good agreement.

  Further calculations are planned in order to compare the physics lists with a higher statistical accuracy and with previous simulations
Thank you!