PROCEEDINGS OF SCIENCE

Radiation damage at LHCb, results and expectations

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The LHCb Detector is a single-arm spectrometer at the LHC designed to detect new physics through measuring CP violation and rare decays of heavy flavor mesons. The detector consists of vertex detector, tracking system, dipole magnet, 2 RICH detectors, em. calorimeter, hadron calorimeter, muon detector which all use different technologies and suffer differently from radiation damage. These radiation damage results and the investigation methods will be shown. The delivered luminosity till July 2011 was about 450 pb^{-1}. The Vertex detector receives the highest particle flux at LHCb. The currents drawn by the silicon sensors are, as expected, increasing proportional to the integrated luminosity. The highest irradiaton regions of the n-bulk silicon sensors are observed to have recently undergone space charge sign inversion. The Silicon Trackers show increasing leakage currents comparable with earlier predictions. The electromagentic calorimeter and hadron calorimeter suffer under percent-level signal decrease which is monitored to achieve a 1% precision in the energy calibration. The Outer Tracker observes no beam induced radiation damage so far. The RICH detectors see no significant irradiation effects as expected. To investigate irradiation effects in a muon system additional monitoring tools are in development, with current tools no radiation damages have been detected.

XXIst International Europhysics Conference on High Energy Physics
21-27 July 2011
Grenoble, Rhônes Alpes France

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 http://pos.sissa.it/

PoS(EPS-HEP2011)395

1. Introduction

The LHCb detector is a single-arm spectrometer [1] designed to detect new physics through measuring CP violation and rare decays of heavy flavor mesons. The detector ran successfully in the last 2 years in which a luminosity of about 450 pb^{-1} was delivered (July 2011). The instantaneous luminosity is lower compared to ATLAS or CMS, but the particle density is very high due to the forward geometry.

2. Silicon detectors

The Vertex Locator is exposed to a high and strongly non-uniform radiation dose. The sensor currents are monitored as a function of voltage and temperature. The expected increase in bulk damage current proportional to the integrated luminosity is observed and annealing is visible during warmed up periods. The analysis of currents versus temperature has allowed to separate out surface and bulk damage. Observing the voltage that must be applied to minimise the noise in the detector has allowed an effective depletion voltage to be measured. The charge collection efficiency as a function of voltage is measured to extract the effective depletion voltage. The measures of depletion voltage have shown that the n-type bulk silicon sensors initially dropped their depletion voltage with fluence, and the tips of the most heavily irradiated sensors have now undergone space charge sign inversion.

The Silicon Trackers are expected to degrade under the LHC irradiation but should stay operational and efficient for 10 years of operation. As for the Vertex Detector monitoring tools like charge collection efficiency scan, noise scan and monitoring leakage currents are employed. The detected leakage currents increase proportional to the integrated luminosity. The observed effects are comparable with the predictions.

3. RICH Detector

Although no radiation effects are expected in the RICH detectors the Cherenkov photon yield, Cherenkov angle resolution and background signals are continuously monitored. So far no significant radiation inducced damage has been observed.

4. Outer Tracker

The Straw tube drift chamber detector showed in lab tests an reduction of gas gain after moderate irradiation with a source. A contamination of the counting gas through the out gassing of the plastifier di-isopropyl-naphthalene in the epoxy glue Araldite AY103-1 causes this ageing [2], [3]. To check the already installed Outer Tracker monitoring tools for in-situ checks were developed. The first method uses a scanning frame with which the gain of 9 modules can be measured independently and it is possible to irradiate one module during technical stops. For this method a strong ^{90}Sr source is used. These tests confirmed the lab results, but no LHC beam induced radiation damage is visible so far. A second method measures the hit efficiency with tracking by scanning the preamplifier threshold values per layer during normal beam time. It confirms that the Outer Tracker shows no radiation damage after roughly 137 pb^{-1}.

PoS(EPS-HEP2011)395

5. Calorimeters

The calorimeters are expected to degrade under the LHC irradiation. To investigate the effects several methods are in use to achieve a energy calibration with 1% precision. For the electromagentic calorimeter a LED calibration system, the π^0 mass and the ratio of energy and momentum are used. The reconstructed π^0 mass drops with irradiation dose. The inner area is affected most, middle and outer area show smaller effects. The PMT degradation is probably one part, but the biggest amplitude loss comes from optical fiber degratation. The E/p ratio method confirms this gain change.

For the hadron calorimeter a LED calibration system and ^{137}Cs scans during technical stops are used to monitor the signal decrease. An expected gain reduction in the central region has been observed after an integrated luminosity of about 95 pb^{-1}.

6. Muon Chambers

The Muon Chambers are not expected to show any irradiation effect [4] and no efficiency drop has been observed so far. After the 2010 run one chamber was opened for visible inspection and no deposits or etching related to the 5% CF_4 in the gas mixture. Additional monitoring tools are in development.

7. Conclusion

LHCb was designed to search for new physics through measuring CP violation and rare decays of heavy flavor mesons. In the last 2 years LHCb ran successfully and a luminosity of about 450 pb^{-1} (July 2011) was delivered. Radiation damages are expected for most sub-detectors. So far the silicon detectors show increasing leakage currents and the vertex detector shows in addition full type inversion as expected. The Calorimeters exhibit expected percent-level signal decrease which is precisely monitored to achieve a energy calibration with a 1% precision. The Outer Tracker and the Muon Chambers radiation damages are monitored, but so far no radiation damage has been found for these sub-detectors. The RICH Detectors neither expect nor show radiation damages. The aging effects seen in the different LHCb sub-detectors are expected and don't deteriorate the successful running of LHCb.

References

[1] A. A. Alves *et al.* [LHCb Collaboration], "The LHCb Detector at the LHC", JINST 3 (2008) S08005.

[2] S. Bachmann *et al.* , "Ageing in the Outer Tracker: Phenomenon, Culprit and Effect of Oxygen", NIM A617 , 202 (2010)

[3] N. Tuning *et al.* , "Ageing in the Outer Tracker: Aromatic Hydrocarbons and Wire Cleaning", NIM A656 , 45 (2011)

[4] M. Anelli *et al.*,"Extensive ageing test of two prototypes of four-gap MWPC for the LHCb muon system", Note LHCb-2004-029, http://cdsweb.cern.ch/record/733605