The production of radiation tolerant vacuum phototriodes and their HV filters for the Compact Muon Solenoid endcap electromagnetic calorimeter

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Abstract:

The particle detectors which will operate at the Large Hadron Collider (LHC) face unprecedented challenges in both the number of active detector elements and in operating without maintenance in a high radiation environment for many years. In the Compact Muon Solenoid (CMS) detector the scintillating crystal electromagnetic calorimeter uses vacuum photodetectors in the endcap where the lifetime neutron and hadron fluence is too high for the silicon avalanche photodiodes used in the barrel.

Over 15000 radiation tolerant vacuum phototriodes (VPT) have been now been produced by industry for the endcap calorimeter. These single gain-stage photomultipliers have to operate for a decade in an environment which has both a significant lifetime dose (up to 20 kGy) from electrons and gamma rays and a high lifetime neutron fluence (up to nearly $10^{15}$ for $E>$100 keV).

This paper discusses the steps taken during both the development and production of the VPT to ensure that even at the inner edge of the endcap calorimeter the response to the scintillation light from the lead tungstate scintillator will not be degraded by more than 10% during the operational lifetime of the experiment. Data from the quality assurance procedures and radiation induced degradation of complete VPT devices will be presented.

In addition to the VPT other components of the endcap calorimeter are also exposed to a similarly intense radiation field. We discuss in particular the signal and high-voltage cable selection and the quality assurance procedures used on the passive components (resistors and capacitors) used in the critical high-voltage filter cards. Data on the electrical performance of components and complete filter-card assemblies after irradiation will be presented, including changes in noise, nominal value and leakage current.

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