Measurements and simulations of surface and bulk radiation damage effects in silicon detectors for phase II CMS outer tracker

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Introduction

- From 2026 the HL-LHC will start, with a very high fluence, up to $1 \times 10^{15}$ MeV (2$ \times $10$^{15}$) n/cm$^2$ in the outer (inner) tracker. A new tracker detector will be installed in CMS.
- Two different Hamamatsu Photonics (HPK) sensor technologies have been investigated as support for the final choice: standard FZ290 and thinned FZth240.
- An intense activity on the Si/SiO$_2$ surface and bulk radiation damage effects have been carried out:
  - development of a surface radiation damage effects model based on [1];
  - measurements on the test structures before and after irradiations:
    - X-rays
    - X-rays and neutrons

In view of the upcoming OT tracker upgrade for the HL-LHC “New Perugia model” will start, with a very high fluence, up to 1 Mrad (SiO$_2$) expected in the outer tracker after 3000fb$^{-1}$

Conclusions

In view of the upcoming OT tracker upgrade for the HL-LHC an intense characterization of irradiated sensor started.

Sensors have been irradiated with X-rays before (50 krad - 70 Mrad(SiO$_2$)) and neutrons then ($1.5 \times 10^{14}$ – $1 \times 10^{15}$ (1 MeV n/cm$^2$)) to study the surface and the combined bulk + surface damage effects.

The new measurements on surface and bulk damages have been presented. Similar behavior between FZ290 and FZth240.

A model for the bulk and surface damages has been developed “New Perugia model” to provide a general radiation damage model. A further [1, 3] comparison between measurements and simulations confirms the validity of the model.

References