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Radiation damage caused by neutron capture in boron doped silicon pixel sensors

CMOS Monolithic Active Pixel Sensors (MAPS) for charged particle tracking provide a unique combination of excellent spatial resolution (~5 µm), light material budget (0.05% X0) and an advanced tolerance to radiation. This makes them the technology of choice for the vertex detectors of various experiments in heavy ion and particle physics including NA61 and CBM.

In this application, the P-doped MAPS are exposed to various kinds of radiation, among them thermal neutrons. Those neutrons create negligible bulk damage according to the NIEL-model. However, this model ignores that thermal neutrons may initiate a nuclear fission of the boron dopants (B10 + n -> Li + Alpha + 3MeV) found in P-doped silicon. It was questioned, whether the fast fission products originating from this reaction might damage the sensors.

We estimated the magnitude of the additional damage based on theoretical arguments. Moreover, we irradiated MIMOSA-19 sensors, which were obtained from the IPHC Strasbourg, with cold neutrons at the PGAA beam line of the FRM-II nuclear reactor. We introduce the results of our theoretical studies and compare the non-trivial radiation damage effects to be expected with our experimental findings. We motivate that the NIEL model may underestimate the damage caused by thermal neutrons in MAPS by one to two orders of magnitude under unfavorable conditions.

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