CONCLUSION

The radiation hardness of silicon detectors depends on the starting material. The results of the epitaxial MACOM silicon #14 of table 5.3 show an increase of N_{eff} as a function of fluence which is three times lower than the standard FZ silicon. The reason for this is still unknown, but it is likely correlated to the presence of impurities introduced into the silicon bulk during the process.

The role of oxygen and carbon for the improvement has been excluded, up to the concentration of $2.5 \cdot 10^{17}$ cm^{-3} and $2 \cdot 10^{16}$ cm^{-3} respectively, as a consequence of the experimental results presented in this thesis. The achieved concentrations are probably too low to affect the formation of final complexes in the clusters caused by the hadron irradiation.

Two ways for the radiation hardening should be followed in future: the investigation of the MACOM #14 silicon in order to find the ingredients which make this material the most radiation hard among all the tested materials, and the introduction of atomic impurities (P, Sn, Ge, …) which are sinks for vacancy, with a concentration comparable to the density of V in clusters ($\approx 10^{20}$ cm^{-3}). This last point represents a hard technological problem. Moreover, the required electrical neutrality of the impurity introduced with such a high concentration limits the choice of the atomic species. Sn for example could introduce thermal donor levels in silicon: the resulting resistivity of silicon could be too low for detector application.

The C-V behaviours and the charge collection properties of irradiated detectors show that the description of the device using the model of the p-n junction is not adequate. The charge collection properties are successfully interpreted using the model of two sensitive regions next to both detector electrodes separated by a region with a low density of free carriers (QNB) and with a weak electric field. This model explains also qualitatively well the C-V characteristic of the irradiated devices (frequency dependence, non linear shape of the log(C) - log(V) curves).

Numerical simulations, which consider the defects introduced by radiation in silicon as donors and acceptors, support this model. The numerical solution of the Poisson equation inside the irradiated devices with the boundary conditions linked to the radiation damage (introduction rates and energy levels of acceptor-like and donor-like defects) provide a full model to interpret the obtained experimental results and to predict the behaviours of irradiated devices.