A new gain layer design – Compensated LGAD

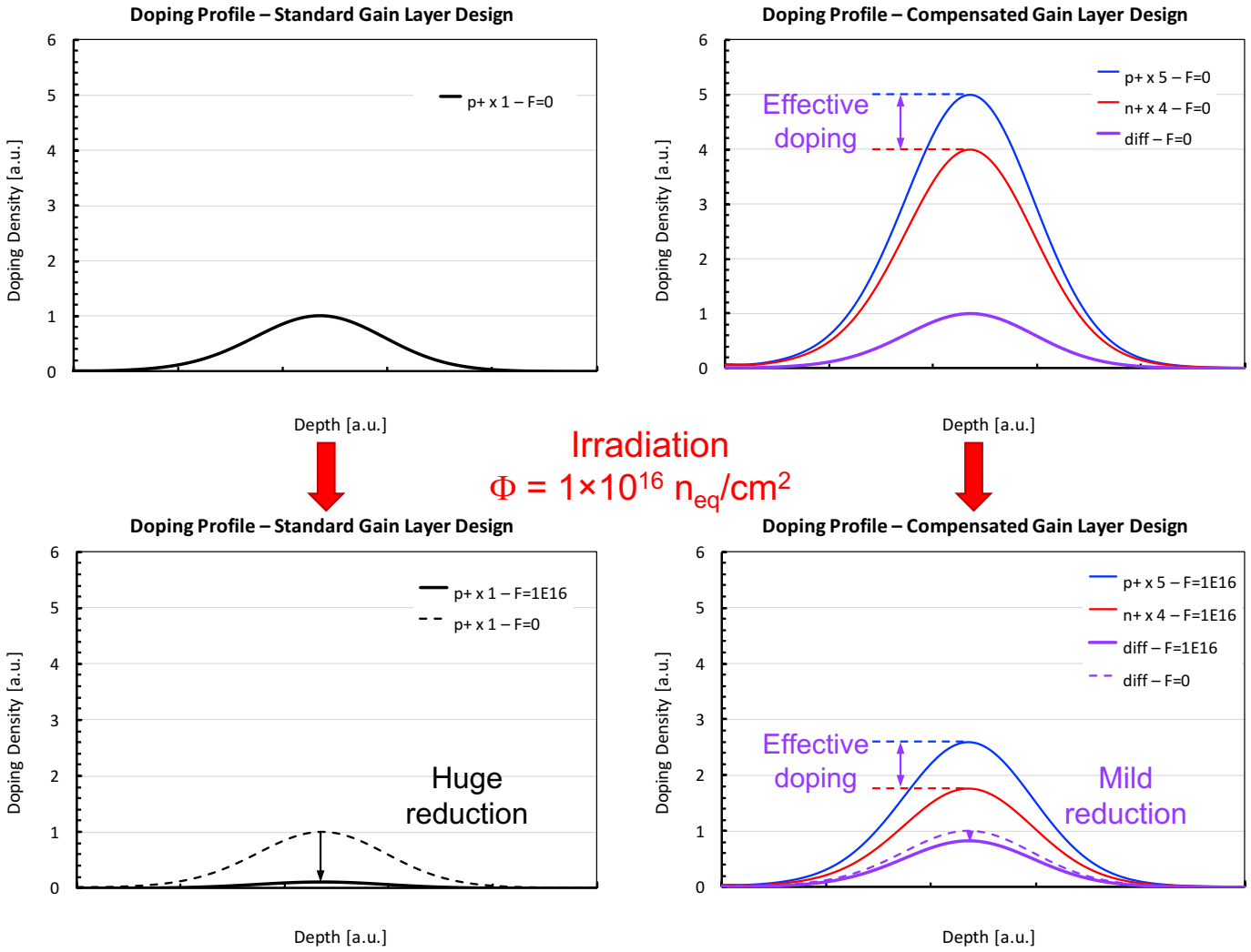
To increase radiation tolerance of the LGAD gain layer we concurrently implant p^+ and n^+ dopants in the gain layer volume

→ **Use the interplay between acceptor and donor removal to keep a constant gain layer active doping concentration**

Many unknown:

- donor removal coefficient, from $\mathbf{n^+(\Phi) = n^+(0)\cdot e^{-c_D\Phi}}$
- interplay between donor and acceptor removal (c_D vs c_A)
- effects of substrate impurities on the removal coefficients

→ **Necessary to study the donor removal at n^+ densities of ~ 10^{16} atoms/cm^3 and above (with and without oxygen)**

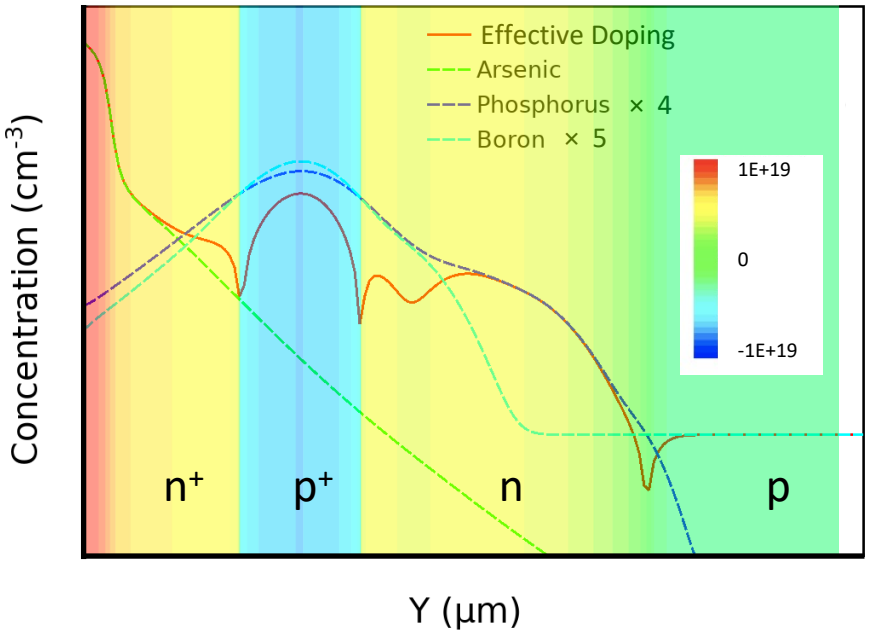


Extras

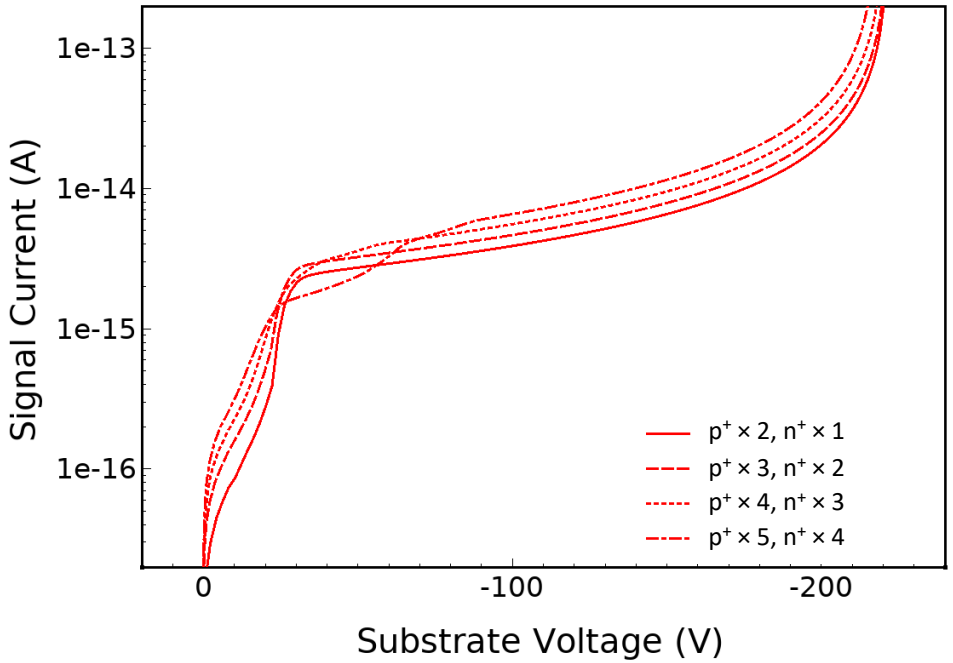
Compensation in Real Life

Process simulations of Boron (p^+) and Phosphorus (n^+) implantation and activation reveal the different shape of the two profiles

Doping Profiles from Process Simulation



I-V from Simulation



→ The simulation of the electrostatic behaviour show that it is possible to reach similar multiplication for different initial concentrations of p^+ and n^+ dopants

Compensation – Doping Evolution with Φ

Three scenarios of net doping evolution with fluence are possible, according to the acceptor and donor removal interplay:

1. **$c_A \sim c_D$**
   p^+ & n^+ difference will remain constant ⇒ unchanged gain with irradiation
   → **This is the best possible outcome**
2. **$c_A > c_D$**
   effective doping disappearance is slower than in the standard design
   → **Co-implantation of Carbon** atoms mitigates the removal of p^+-doping
3. **$c_A < c_D$**
   n^+-atoms removal is faster ⇒ increase of the gain with irradiation
   → **Co-implantation of Oxygen** atoms might mitigate the removal of n^+-doping

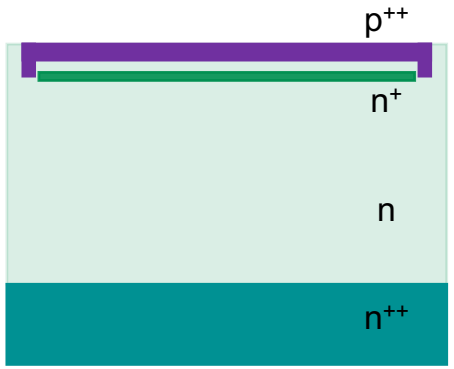
Donor Removal Characterisation

A p-in-n LGAD production batch is foreseen to study the donor removal coefficient, c_D

Donor removal has been studied for doping densities of 10^{12} – 10^{14} atoms/cm^3

We need to study donor removal in a range 10^{16} – 10^{18} atoms/cm^3

NB: Oxygen has for donor removal a very similar effect of Carbon to acceptor removal



p-in-n LGAD

→ **The main goal of the p-in-n LGAD production is to study the c_D evolution and its interplay with Oxygen co-implantation**