# Enhanced lateral drift sensors: simulation and production.

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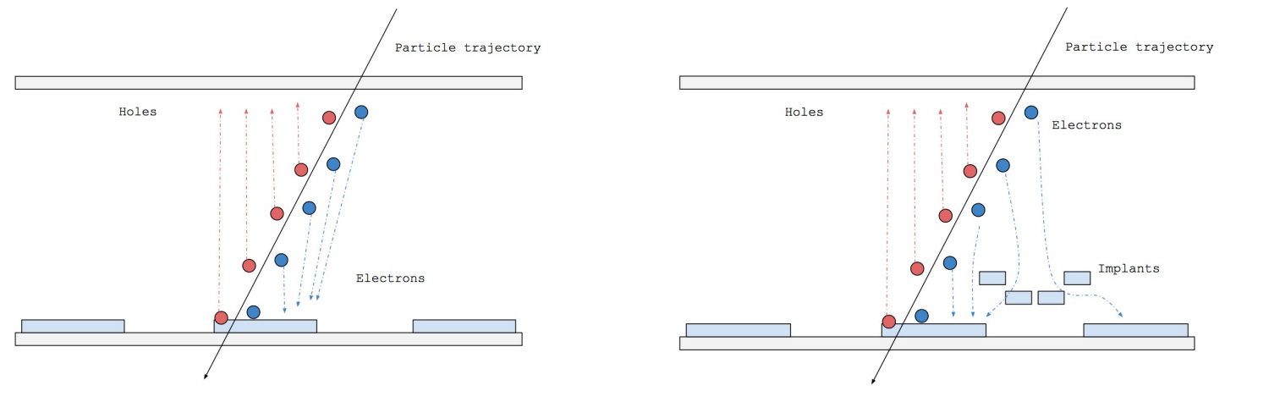
## Introduction

Main Goal - Improve the position resolution of tracking sensors by local manipulation of the electric field

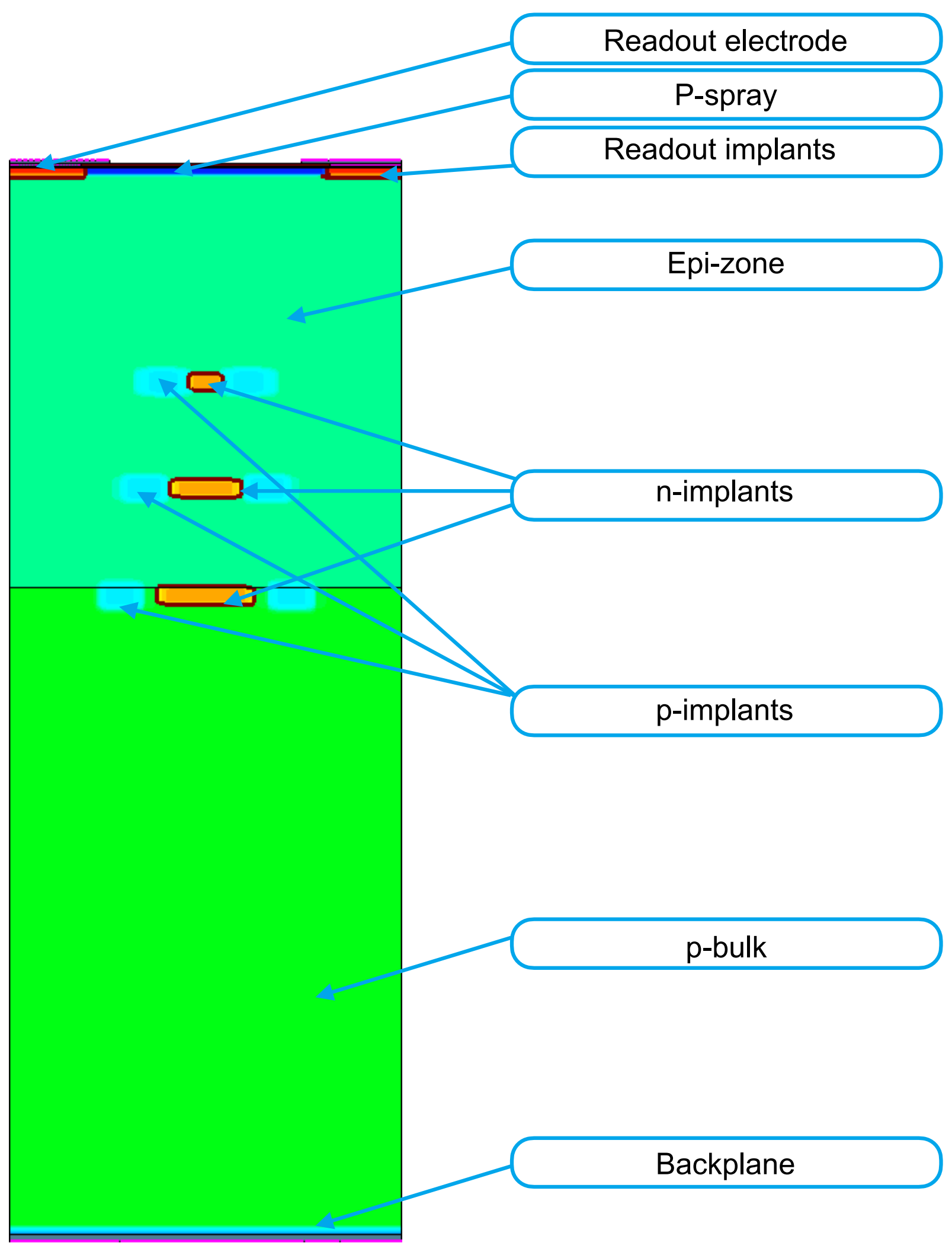
Idea - Improved position resolution rendered possible by increasing the lateral size of the charge distribution during the drift

One of the main goals in the R&D of tracker sensors technology is to increase the position resolution of the particle detector. There are two ways to achieve this. The most common way is to decrease the size of the read-out cell, i.e. to decrease the pixel or strip pitch. But in this case, the number of channels increases, which requires an increased bandwidth for the read-out. The other possibility to improve the position resolution of sensors is to increase the lateral size of the charge distribution already during the drift in the sensor material. In this case, it is necessary to carefully engineer the electric field in the bulk of this so-called enhanced lateral drift (ELAD) sensor. This new design is uses implants deep inside of the bulk. Implants constitute volumes with different values of doping concentration in comparison to the concentration in the bulk. This allows for modification of the drift path of the charge



In ELAD sensors part of the charge are collected at the neighboring strip. The amount of charge sharing depends on the position of the MIP crossing.

## Concept



## Stages of development

- Simulation and optimisation sensor design
- Sensor production
- TCT measurements
- Test beam
- Data analysis

## Simulation and optimisation sensor design

The necessary features of the simulation program:

- simulation of different geometric designs of sensor, adding an “implants”;
- simulation of the electric field in the sensor;
- simulation of the current in readout electrode;
- simulation of trajectory of charge carriers;
- using different modes: with free probe charge or MIP in arbitrary angle.

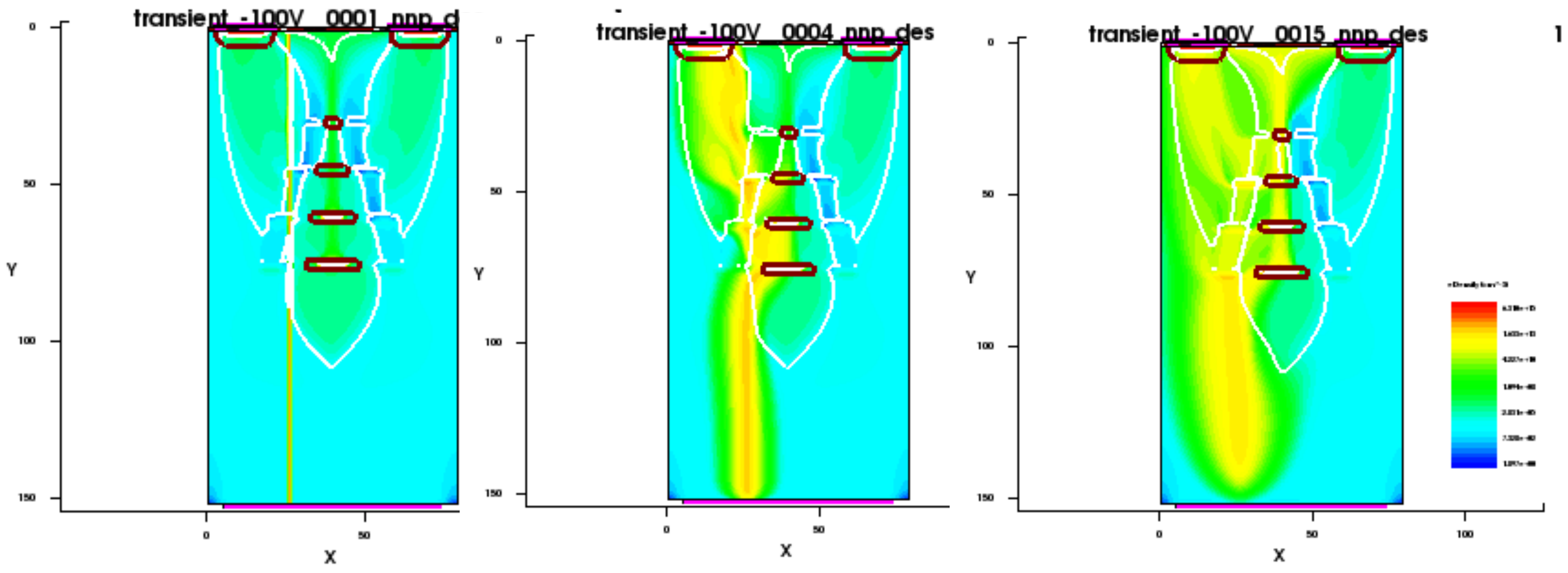
The development of such a detector requires a good understanding of the entire production process. In order to find an optimal geometry and design of the detector, it is necessary to make reliable simulations, which are conducted using SYNOPSYS TCAD.

The parameters that need to be defined are:

- the geometry of the implants;
- implants doping concentration;
- the position inside the sensor.

For a realistic modeling of such implants, process simulations are used to provide input of their production-determined shapes.

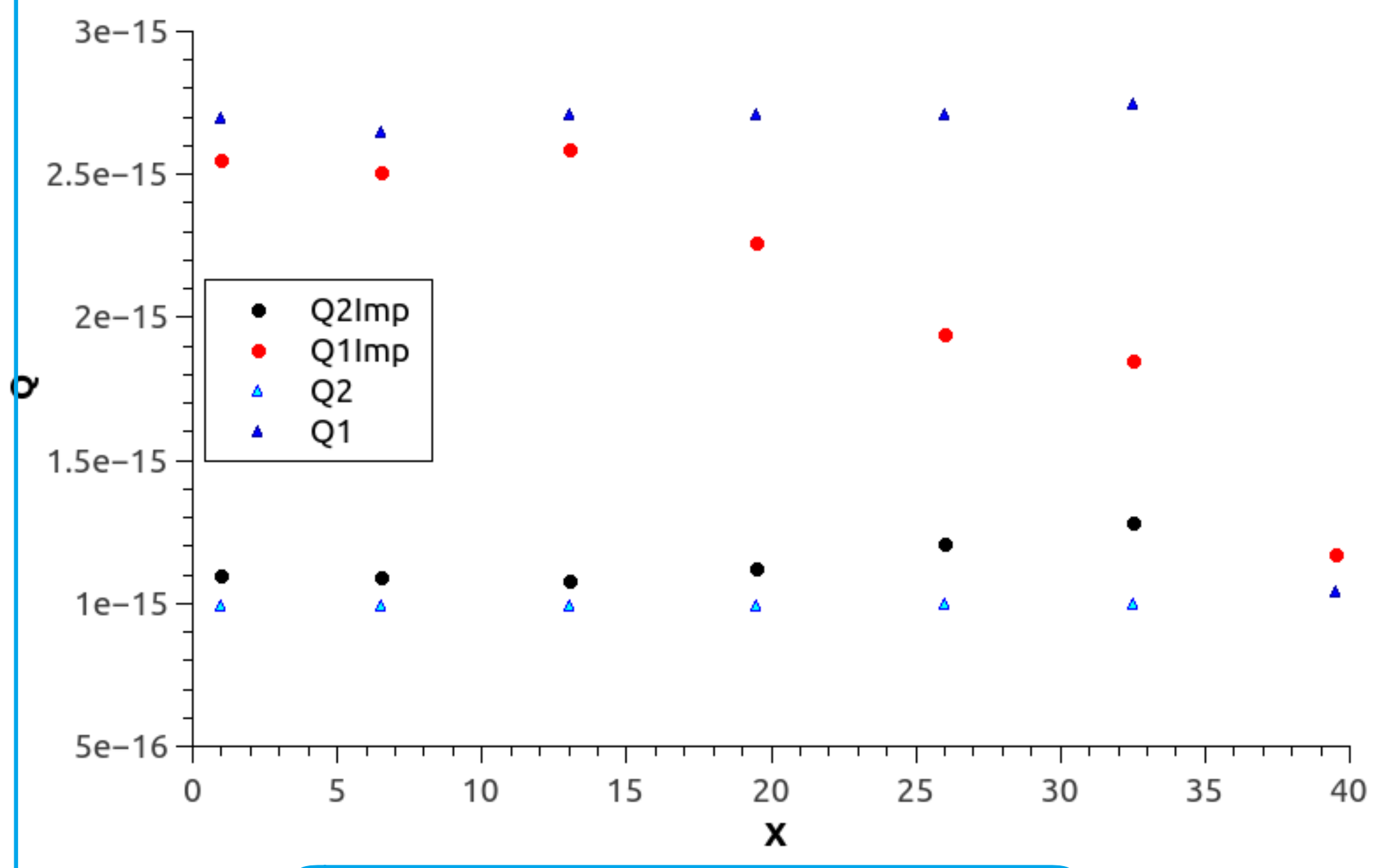
## Drift simulations in TCAD SYNOPSYS



t=1e-12s t=1e-10s t=1,2e-9s

TCAD simulation is a highly versatile tool used in the development of semiconducting sensors. TCAD SYNOPSYS follows the standard finite element analysis scheme. A simulation process starts from the creation of sensors structure, where materials are placed and their properties are defined. Subsequently, a mesh is created. After the meshing process is has finished the device simulation is executed. The time-dependent simulation results are presented. In this type of simulations, a transient simulation is performed to assess the response of a device to traversing particles at definable times. Electron density deposition is presented.

## Charge deposition

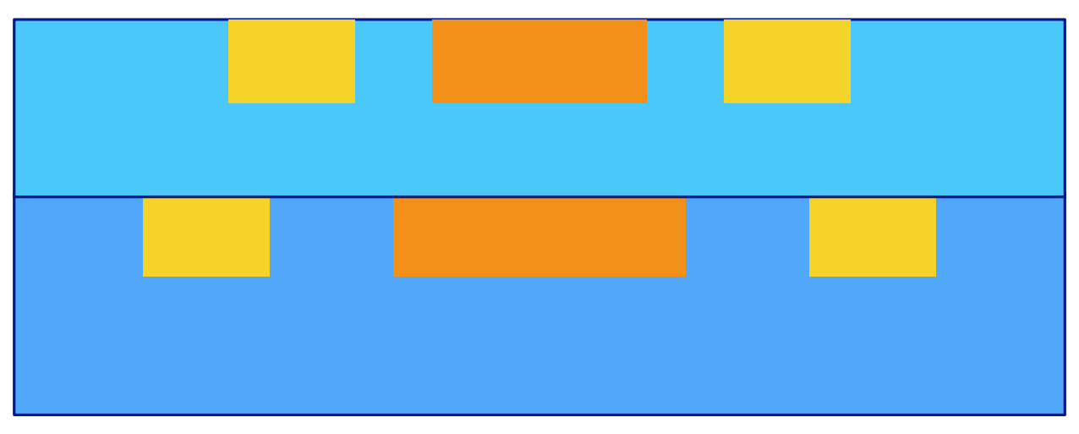


Q1 - collected charge at 1st strip in usual sensor;
Q2 - collected charge at 2nd strip in usual sensor;
Q1Imp - collected charge at 1st strip in ELAD;
Q2Imp - collected charge at 2nd strip in ELAD;
V=100V.

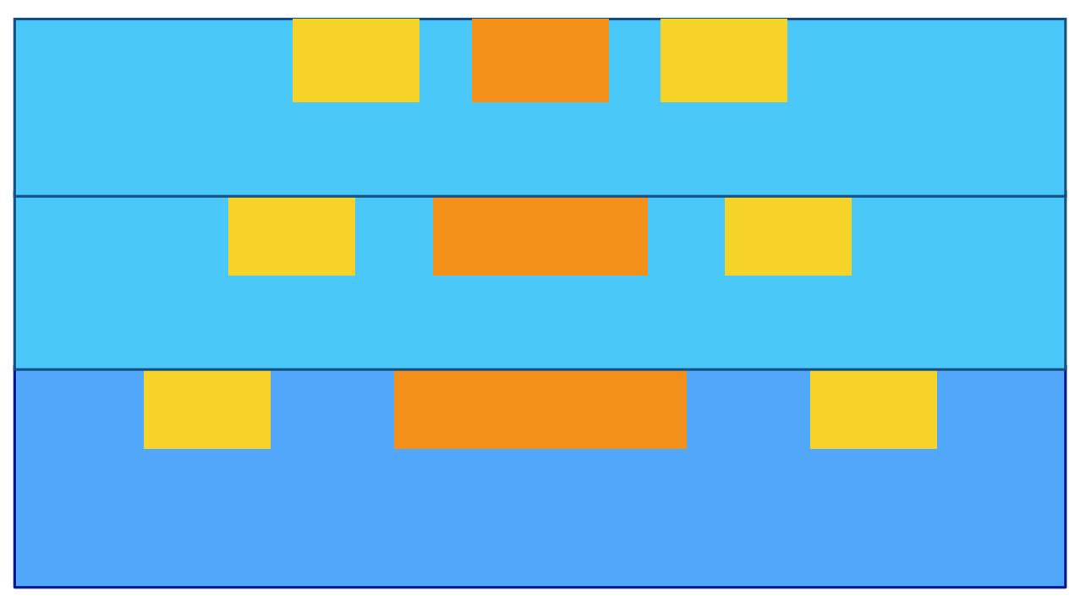
The collected charge as a function of the MIP incident position is shown. The x-axis - position of MIP [μm], the y-axis - collected charge [C]. The plot shows that the ELAD detectors have better charge sharing (red and black dots) than the usual design detectors (blue and light blue triangles).

## Production

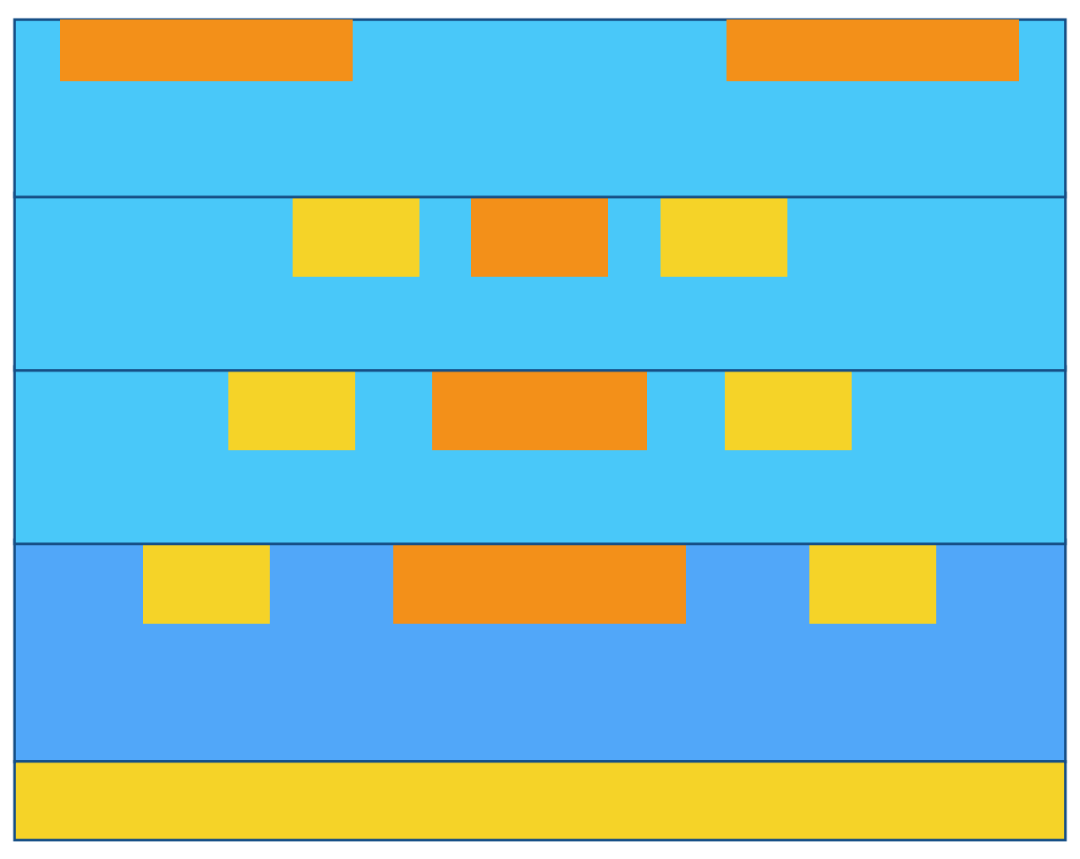
Surface implantation



Epi layer and surface implantation



Epi layer and surface implantation



Epi layer, surface and backside implantation

The first stage of production is p and n surface implantation. Implantation is done by bombarding the wafer with an ion beam of defined energy. After first-time surface implantation wafer is polished and prepared for epitaxial silicon growth.

In the epitaxial growth process, a thin layer is grown on the polished wafer. In course of the growth process, the layer adopts the orientation of the substrate crystal. One of the growth method is the CVD process, in which at approximately 1200°C, a gaseous silicon compound is decomposed with the resulting silicon growing on the crystal substrate.

After epi growth is repeated implantation process. In this case 3 epi layers will be done. After the last epi growth the surface implantation is performed for readout strips and backside implantation. Doping of epitaxial layer is achieved by adding gaseous compounds to the environment.